REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Naval Postgraduate School 6b. OFFICE SYMBOL *(If applicable)*	7a. NAME OF MONITORING ORGANIZATION Naval Postgraduate School
6c. ADDRESS (*City, State, and ZIP Code*) Monterey, CA 93943-5000	7b. ADDRESS (*City, State, and ZIP Code*) Monterey, CA 93943-5000
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b. OFFICE SYMBOL *(If applicable)*	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (*City, State, and ZIP Code*)	10. SOURCE OF FUNDING NUMBERS Program Element No. / Project No. / Task No. / Work Unit Accession Number

11. TITLE (*Include Security Classification*)
A Feasibility Analysis of Implementing C/SCSC Concepts at U.S. Army Depots

12. PERSONAL AUTHOR(S) Anderson, Thomas D.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (*year, month, day*)	15. PAGE COUNT
Master's Thesis	From To	March 1993	100

16. SUPPLEMENTARY NOTATION
The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

17. COSATI CODES			18. SUBJECT TERMS (*continue on reverse if necessary and identify by block number*)
FIELD	GROUP	SUBGROUP	Cost /Schedule Control Systems Criteria, C/SCSC, Earned Value, Performance Measurement, C/SCSC Techniques, Army Depot, Program Management Office, Firefinder Radar, Communications Electronics Command.

19. ABSTRACT (*continue on reverse if necessary and identify by block number*)

This thesis analyzes the feasibility of using Cost/Schedule Control Systems Criteria (C/SCSC) concepts at U.S. Army Depots. C/SCSC compliance is commonly used by the defense industry when contracting with the U.S. Government for large production and R&D (research and development) programs. However, program managers of acquisition programs that opt to have significant work efforts performed at Army depots may also need methods of tracking cost and schedule performance. One method may be the implementation of C/SCSC management techniques at these depots. This thesis analyzes current Army depot methods for controlling and reporting cost/schedule performance. The viability and benefits of using the techniques of C/SCSC are compared to the depot methods. This thesis concludes with recommendations on what aspects of C/SCSC should be incorporated by U.S. Army Depots and guidelines to follow for implementation. The methodology utilized for this thesis can also be applied to other DOD field activities for C/SCSC concept exploration.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION	
[X] UNCLASSIFIED/UNLIMITED [ ] SAME AS REPORT [ ] DTIC USERS	Unclassified	
22a. NAME OF RESPONSIBLE INDIVIDUAL Thomas H. Hoivik	22b. TELEPHONE (*Include Area code*) (408)-656-3301	22c. OFFICE SYMBOL AS/Ho

DD FORM 1473, 84 MAR 83 APR edition may be used until exhausted
All other editions are obsolete

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A Feasibility Analysis of Implenting C/SCSC Concepts at U.S. Army Depots

by

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Submitted in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT
(ADMINISTRATIVE SCIENCES)

from the

NAVAL POSTGRADUATE SCHOOL
March 1993

ABSTRACT

This thesis analyzes the feasibility of using Cost/Schedule Control Systems Criteria (C/SCSC) concepts at U.S. Army Depots. C/SCSC compliance is commonly used by the defense industry when contracting with the U.S. Government for large production and R&D (research and development) programs. However, program managers of acquisition programs that opt to have significant work efforts performed at Army depots may also need methods of tracking cost and schedule performance. One method may be the implementation of C/SCSC management techniques at these depots. This thesis analyzes current Army depot methods for controlling and reporting cost/schedule performance. The viability and benefits of using the techniques of C/SCSC are compared to the depot methods. This thesis concludes with recommendations on what aspects of C/SCSC should be incorporated by U.S. Army Depots and guidelines to follow for implementation. The methodology utilized for this thesis can also be applied to other DOD field activities for C/SCSC concept exploration.

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I. INTRODUCTION

A. PURPOSE

The purpose of this thesis is to conduct a feasibility analysis of using Cost/Schedule Control Systems Criteria (C/SCSC, also called "Earned Value") management techniques at U.S. Army Depots. C/SCSC compliance is normally used by the defense industry when contracting with the U.S. Government for large Research & Development (R&D) projects. However, program managers of acquisition programs that require significant work at Army depots may also need methods for tracking cost and schedule. One method may be the implementation of C/SCSC management techniques at these depots. This thesis provides a comparative analysis of earned value techniques and depot reporting systems.

B. BACKGROUND

In view of declining U.S. Defense budgets, Army acquisition program offices are more concerned than ever that program funds are spent effectively and efficiently with industry and other Government field activities, including test centers, depots, arsenals and research laboratories. Increased efforts are being put forth by program offices to ensure that both industry and Government field activities employ effective cost

and schedule control systems when using program funds in support of their programs.

Nearly 25 years ago, the Department of Defense adopted Cost/Schedule Control Systems Criteria (C/SCSC) for significant contracts and subcontracts (excluding fixed price contracts) within all acquisition programs. Department of Defense Instruction 5000.2 (part 11, section B) also states that these criteria will be applied to significant work efforts accomplished by Government activities when meeting the same or similar dollar thresholds. However, with the exception of a few isolated cases, this concept has not been used by Government field activities.

The Program Manager of the Army Data Distribution System (ADDS), whose program is spending significant amounts of program funds with both industry and Government field activities, was concerned about the field activities' cost/schedule management. The ADDS program has several contracts with industry that use the earned value concept, but the work efforts, or "contracts," with Government activities did not. The ADDS program currently has significant work efforts at the following Government field activities:

- Sacramento Army Depot
- Tobyhanna Army Depot
- Marine Corps Tactical Software Support Activity
- Electronic Proving Ground, Fort Huachucha
- Test and Experimentation Command (TEXCOM)

The concern of the ADDS Program Manager provided the basis for this thesis.

C. THESIS OBJECTIVES

The objective of this thesis is to provide future program managers insight and background information on the earned value concept and its feasibility for use within U.S. Army depots. It examines the cost/schedule management problem confronted by program managers whose programs may involve significant acquisition support from depots. It will enable individuals in program offices to understand the importance of the earned value concept in managing program cost and schedule. This analysis should benefit program managers when having to decide whether to require depots to comply with C/SCSC or to allow the depot to use its standard reporting systems.

A major product of the earned value concept, the Cost/Schedule Status Report (C/SSR), is also examined in this thesis. The C/SSR was designed for smaller, non-major acquisition programs in an effort to minimize the many "program unique" reports.

D. RESEARCH QUESTIONS

The primary research question is:

"Should the earned value concept be incorporated at U.S. Army Depots?"

Subsidiary research questions are:

- What is the earned value concept and how is it used?
- What key characteristics of earned value are essential for its application?
- What significant acquisition efforts performed by Army depots lend themselves to the use of the earned value concept?
- To what extent is earned value currently being used by Army depots?
- What factors must be addressed before earned value can be implemented at Army depots?
- To what extent can earned value be applied to Army depots?
- What is the value of applying the earned value concept to Army depots performing significant acquisition efforts?

E. SCOPE

This thesis will assess the utility of employing the earned value concept in US Army depots only. It will focus on three depots in particular - Sacramento, Letterkenny and Tobyhanna Army depots. Two current Army programs, the Army Data Distribution System (ADDS), and the Firefinder Radar program, will be assessed as examples for cost and schedule management by the depots supporting these programs.

This thesis will focus on the use of the C/SSR, since most work efforts accepted by depots do not require the use of the Cost Performance Report (CPR). The threshold for the C/SSR is normally set for contracts valued over $2 million and for a duration of 12 months or more, which is the range of many depot work efforts for Army acquisition program offices. The

CPR is a more detailed report using the earned value concept. It is required when contracts are valued at $60 million or more in research, development, test and evaluation and $250 million or more in procurement (in 1990 constant dollars) [Ref. 7:p. 11-B-2]. However, it is not likely that any depot will be assigned a single work effort valued over the thresholds for the CPR.

F. METHODOLOGY

Research for this thesis consisted primarily of an indepth literature review and interviews with key personnel involved with cost and schedule management. This thesis utilized the guidelines set forth in the Cost/Schedule Status Report Joint Guide, which provides Department of Defense instructions for cost/schedule management for non-major acquisitions. In addition, Government reports, instructions, directives, textbooks, theses and periodicals were used for information sources. The Defense Logistics Studies Information Exchange (DLSIE) and the Defense Technical Information Center (DTIC) provided other sources of information. A thorough review of operating procedures and on-site visits of the three depots provided valuable information on their current cost/schedule management techniques.

Most of the information on depot operations and reporting, however, came from interviews with key personnel within the three depots. The personnel interviewed are all involved with

cost, schedule and production management of various acquisition programs. Interviews also included numerous people from acquisition program offices, the Depot Systems Command Headquarters (DESCOM) and several members of private industry. Information on the use of earned value in private industry came from interviews with personnel from Hughes Aircraft, of Fullerton, California. Hughes is the prime contractor for the ADDS program and has recently been validated for C/SCSC after approximately five years of review and examination by Government program office personnel.

In addition, in April of 1992, the researcher attended a National C/SCSC Workshop in San Francisco, California. This forum furnished vital insights into the widespread use of C/SCSC and the earned value concept. The workshop was attended by professionals from the DOD staff, the Performance Management Association, defense industry, the National Security Industrial Association, the Department of Energy, the Society of Cost Estimating and Analysis, and the military services.

II. FUNDAMENTALS OF THE EARNED VALUE CONCEPT

A. HISTORY/BACKGROUND

Earned value is just one of several concepts embodied in the Cost/Schedule Control Systems Criteria (C/SCSC), but it is the one concept that many consider to be fundamental to performance measurement. Earned value is the value of the work accomplished as measured in terms of the budget planned (a baseline of scheduled work) for that work. A complete description of earned value, however, cannot be given without a brief background of the concept and C/SCSC.

In the late 1950s, Government program managers were attempting to reverse the trend of large budget and schedule overruns of major acquisition programs. Often, these overruns were unpredictable and not identified until near contract completion. Two network scheduling concepts emerged during this time, which originated in the defense community, and were implemented by the Government: PERT (program evaluation and review technique) and CPM (critical path method). PERT was developed by the Navy and the management consulting firm Booz, Allen and Hamilton -- to support the planning of the Polaris Missile project. Meanwhile, J.E. Kelly of Remington Rand and M.R. Walker of Dupont introduced the CPM.

Both had a similar approach of linking together the planned events and tasks in an attempt to show the relationships and constraints between them, but differed in their treatment of time and cost. PERT used stochastic or probabilistic network models, while CPM used deterministic network models. Thus, PERT was designed to handle the uncertainties that exist in predicting the time necessary to complete various project activities. CPM, which uses single value best estimates of both time and costs, was concerned more with the time/cost tradeoff, that is, the tradeoff between project completion date and project cost [Ref. 30:p. 383]. These networking concepts initially received high acclaim and in the early 1960s, the Government attempted to apply PERT/CPM to all major contracts.

Eventually, resources were added to the PERT scheduling technique, and thus it became known as PERT/Cost. The PERT/Cost method was a very important phase of the evolution of cost and schedule management because it suggested the idea of planning and scheduling program work with periodic performance measurements. It also provided the capability to estimate project completion times and costs. This new concept was called "Earned Value Management," [Ref. 14:p. 23].

However, the defense industry basically ignored the technique because of poor implementation by the Government and the lack of supporting automation equipment. The Department of Defense "proclaimed" Pert/Cost to be the single management

technique to be used on all major defense contracts. Experienced industry officials and military officers naturally resented being told what management technique to use on their contracts, and thus PERT/Cost quietly faded.

In 1963, the United States Air Force formed the Cost/Schedule Planning & Control Specifications group, which conceived the idea that a contractor's existing management control system should satisfy a certain set of "criteria," rather than requiring implementation of a new system. The Air Force Minuteman missile program included this set of management criteria in the contract statement of work and pioneered the implementation of the criteria approach as a realistic appraisal of a contractor's internal management control systems [Ref. 11:p. 14]. This approach included several improvements and carried over the work breakdown structure and work packages ideas from PERT/Cost. It was designated as the Earned Value Concept and referred to the work actually accomplished as measured in terms of the baseline budget planned for that work [Ref. 11:p. 14]. The resulting set of standards or criteria, called Cost/Schedule and Control Specification (C-Spec) was officially adopted by the Air Force Systems Command in June 1966.

In December 1967, the Department of Defense issued DOD Instruction 7000.2, Performance Measurement for Selected Acquisitions. Henceforth, DOD standardized the requirements with a set of 35 criteria that a contractor's management

information system would have to meet. Even with this policy requirement in place, the C/SCSC approach had a slow start because there were no formal guidelines that explained the earned value concept and how it could be consistently applied. Therefore, a Tri-Service C/SCSC Joint Implementation Guide was issued in 1970, and by 1972 all three Services were actively implementing C/SCSC [Ref. 11:p. 14].

The implementation guide has been updated several times since then, but the criteria remain the same today. Thus what started in one Air Force project has spread to the Army and the Navy, to other Federal agencies, including NASA, the Departments of Energy and Transportation and even to the Australian Department of Defense.

1. The C/SCSC Criteria

As stated earlier, only the implementation of C/SCSC has been changed or improved while the criteria have remained unchanged in 25 years. The C/SCSC contain 35 criteria that can be grouped into five categories. These categories generally deal with the following requirements [Ref. 31:p. 17]:

a. Organization

These criteria require that the contractor's system provide for clear definition of the overall contractual effort with a work breakdown structure serving as a framework for displaying subdivisions of effort. Integration of the work

breakdown structure with the functional organization structure is required in order to provide for identification of key positions and assignment of responsibility for work tasks. Additionally, integration of the planning, scheduling, budgeting, work authorizing and cost accumulation subsystems is a key element in an effective control system.

b. Planning and Budgeting

All authorized work must be planned and scheduled in a manner that describes the sequence of work and identifies the significant task interdependencies required to meet the development, production, and delivery requirements of the contract. Establishment of the performance measurement baseline is the key requirement of this section.

c. Accounting

Cost of completed work must be accumulated from the bottom up as directly as possible without need for allocations in summation. Cost of materials should be handled on an applied cost basis, if possible, in order that the cost of work does not include cost of materials on order or in inventory. The accounting system should provide for accurate cost accumulation and assignment of costs to cost accounts in a manner consistent with the budgets using recognized, acceptable costing techniques and allows for comparison with the baseline. Direct costs should be summarized from cost accounts into the work breakdown structure without allocation

of a single cost account to two or more work breakdown structure elements. All indirect costs attributable to the contract must be recorded and allocated. If applicable, the accounting system must be able to identify unit cost, equivalent unit costs, or lot costs.

d. Analysis

Actual versus planned performance comparisons are required by this group of criteria. Comparing the budgeted cost of work scheduled and the budgeted cost of work performed on a monthly basis allows for the analysis of variances from the baseline. Thresholds for variance analyses should be established to avoid excess effort which may otherwise result from analyzing every single variance. It is important that variances be examined in terms of increments or aggregations of work which are large enough to produce significant information. Analyzing individual work packages would not be cost effective. Based on performance to date, on commitment values for materials, and on estimates of future conditions, the analysis should provide for revised estimates of cost at completion for work breakdown structure elements identified in the contract. This estimate can be compared to the contract budget base and the latest statement of funds reported to the Government.

e. Revisions and Access to Data

Incorporation of authorized changes are dealt with in this set of criteria. Emphasis is placed on the need to retain a meaningful performance measurement baseline. Requirements include reconciliation of estimated costs at completion with fund requirements reports and original budgets for those elements of the work breakdown structure. Provisions must be in place for access to data by Government personnel for evaluations of criteria compliance.

The Department of Defense recognized that there is no single set of management control systems that will meet every need for performance measurement. The criteria approach, however, provides a basis for determining whether the management control systems of a contractor are acceptable. A full listing of the 35 criteria is presented in Appendix A.

2. Thresholds for Compliance

In 1991, the DOD consolidated most of the acquisition policies and procedures of the DODI 7000 series into DODI 5000.2. Part 11 of DODI 5000.2 describes C/SCSC and the thresholds of contract values for mandatory compliance with the criteria. It states that compliance with C/SCSC shall be required on significant contracts and subcontracts within all acquisition programs, unless waived by the milestone decision authority [Ref. 7:p. 11-B-2]. Significant contracts are defined as:

> Research, development, test, and evaluation contracts valued at $60 million or more; or procurement contracts with a value of $250 million or more (in fiscal year 1990 constant dollars).

Part 11-B further states that compliance with C/SCSC shall also be required for "significant acquisition efforts" performed by Government field activities for program offices. However, the instruction provides no thresholds nor a definition of "Government performed significant acquisition efforts". A representative of the Office of the Assistant Secretary of Defense (Comptroller) explained that the instruction was written as such to give the Government program manager the flexibility to determine if C/SCSC should be used in Government field activities supporting his program.

In addition, DODI 5000.2, part 11-B states that compliance with C/SCSC shall not be required on firm fixed-price contracts, time and material contracts, and level-of-effort contracts, unless exception is made by the milestone decision authority. The original purpose of the earned value concept was to monitor and control costs, which obviously protected the buyer when the buyer was sharing the risks with the contractor. With a fixed-price contract, more of the risk is shifted from the buyer to the contractor, so the safe-guards and the predictive tools of earned value are not necessary in this regard. The final price is guaranteed up front with a fixed-price contract, so any overruns are borne by the contractor.

B. OBJECTIVES OF THE EARNED VALUE CONCEPT

Government program managers have an inherent duty to ensure that program resources are spent efficiently and economically mainly because their efforts are funded by taxpayers' monies. When contracting with private industry for goods and services, program managers have to have accurate and reliable performance measurement data to do this. Before C/SCSC, there were no methods to objectively assess program performance, either before or after work was started. Rather than imposing management control systems onto contractors, the criteria concept merely specifies the minimum requirements that a contractor's control system must satisfy. It has to allow for the verification of work performed, and to generate reliable and measurable projections of the total contract cost.

Two formal objectives of the criteria approach, as restated in Arthor D. Little's C/SCSC White Paper, in 1986 [Ref. 17:p. 1] are:

- For contractors to use effective internal cost and schedule management control systems, and
- For the Government to be able to rely on timely and auditable data produced by those systems for determining product-oriented contract status.

Contractors are still able to organize their work and control systems in the manner best suited to their individual environments and may establish and operate to the internal methods of their choice. It is important to note that the

criteria themselves do not require the submission of any reports, but only specify the reporting capabilities the contractors must have and the types of data that the systems should be able to produce. The type and detail of reports are selected by the Government program office, depending on dollar value of the contract and other requirements.

Department of Defense Instruction 5000.2, part 11-B states that the purpose of C/SCSC is to provide contractor and Government program managers with accurate data to monitor execution of their program [Ref. 7:p. 11-B-1] and to:

- Preclude the imposition of specific cost and schedule control systems.
- Provide adequate basis for responsible decision making by both contractor management and DOD component personnel by requiring the contractors' internal management control systems to produce data that:
    - Indicate work progress.
    - Properly relate cost, schedule, and technical accomplishment.
    - Are valid, timely, and able to be audited.
    - Provide DOD component managers with information at a practical level of summarization.
- Bring to the attention of DOD contractors, and encourage them to accept and install, management control systems and procedures that are most effective in meeting requirements and controlling contract performance.

C. KEY ASPECTS OF THE EARNED VALUE CONCEPT

One of the primary purposes of using the earned value concept is to provide advance indications of potential and

actual program problems before they become significant. In addition to the advance indication of problems, earned value measurements can also identify specific problem areas, down to the work center level. However, in order to obtain the benefits of earned value measurements, three key items of a management control system are essential for its use:

- Work Breakdown Structure (WBS)
- Performance Measurement Baseline (PMB)
- Consistent Earned Value Measurement Techniques.

1. Work Breakdown Structure

The WBS is a method which defines the total work of a program or contract into manageable work packages. MIL-STD-881A is the DOD document that provides preparation instructions and DOD Directive 5010.21 is the implementing directive for its use. The military standard defines a work breakdown structure as:

> A product oriented family tree composed of hardware, services and data which result from project engineering efforts during the development and production of a defense material item, and which completely defines the project/program. A WBS displays and defines the product(s) and relates the elements of work to be accomplished to each other and to the end product.

If a WBS is displayed on a wall, it can resemble an organizational chart, graphically describing a given contract's statement of work, specifically calling out the hardware, software, and services to be performed [Ref. 12:p. 28]. It starts out with a single box, into which everything

below will flow. The top box represents the total system and is called WBS level 1. Lower levels are appropriately numbered 2, 3, and so on (see Figure 1). Levels 1-3 are normally referred to as Project WBS and levels 3-5 are called the Contractor WBS. Most contracts will call for reporting cost/schedule data in detail down to level 3, although actual cost collecting comes from all WBS levels.

The WBS technique is important to both the buyer and contractor for several reasons. One is that a standardized WBS reporting format allows the buyer to compare proposals for new efforts and estimates to complete an existing job against actuals for work already accomplished for effort at the same WBS level. A second reason is that it helps the contractor plan new projects and demonstrate to the Government the contractor's knowledge about the proposed new job. Finally, it is important because it aids in the definition of the work to be done in total, and it allows the contractor to break the total effort down into manageable work teams for purposes of specific procurement packages.

In order to assign functional responsibility for the tasks to be performed, integration of the organizational structure with the work breakdown structure is necessary. A matrix arrangement is the most common technique used by contractors to accomplish this integration effectively. As a result, the intersection of these two structures is often selected as a convenient point for collecting and analyzing

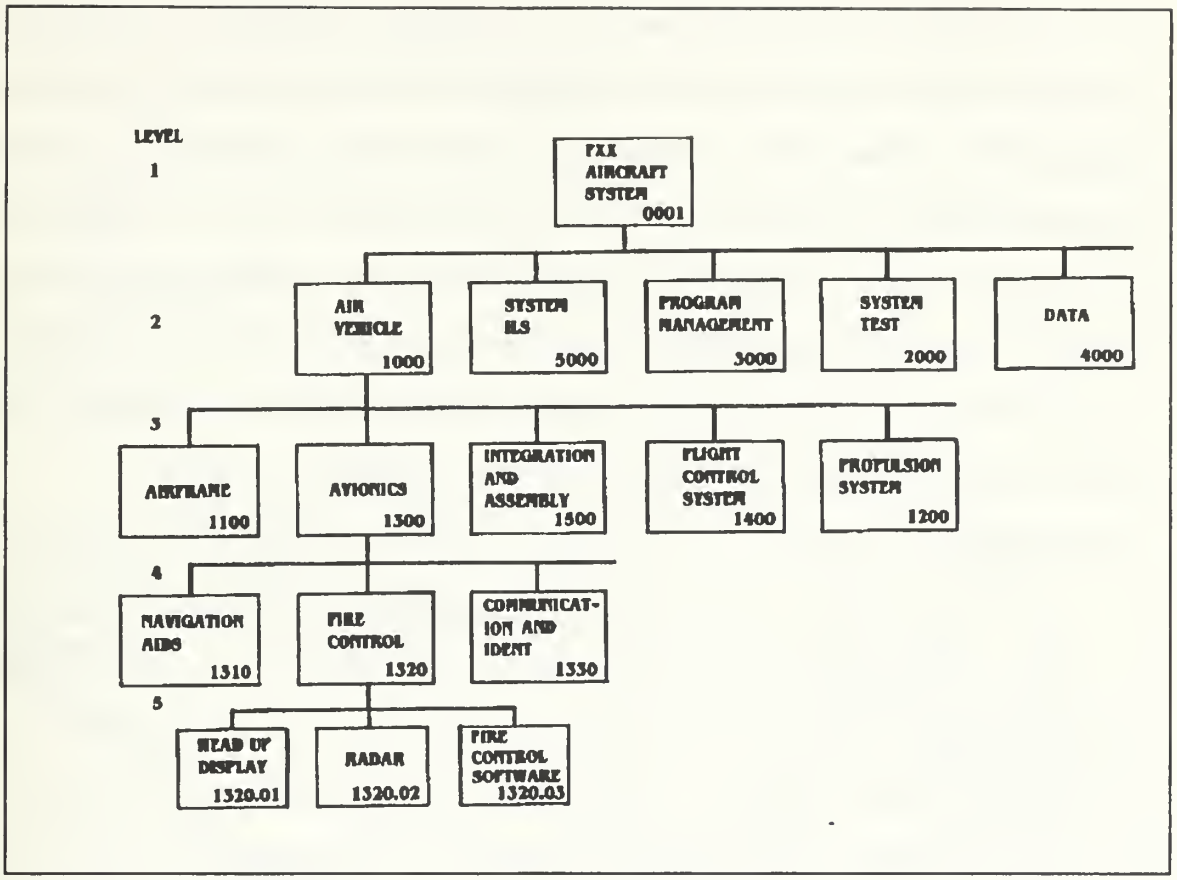

Figure 1. Organizational Chart WBS [Ref. 34].

costs and other information before summarizing for higher levels of management. This intersection point establishes what is often called the cost account or cost control account. The cost account is normally the lowest level where performance measurement is managed based on costs information obtained from work packages.

2. Performance Measurement Baseline

Once a WBS is established, the next step is to schedule the work and allocate program resources to each task to a baseline. This "baseline management," is the beginning

of earned value measurement. This is critical in assessing performance, in that one must know what to measure against in specific terms on a periodic (monthly) basis. Baseline management includes the establishment of a baseline, maintaining it and monitoring performance (variances from the baseline), which is called performance measurement. Figure 2 graphically presents the three-step iterative process of the performance measurement baseline [Ref. 14:p. 97].

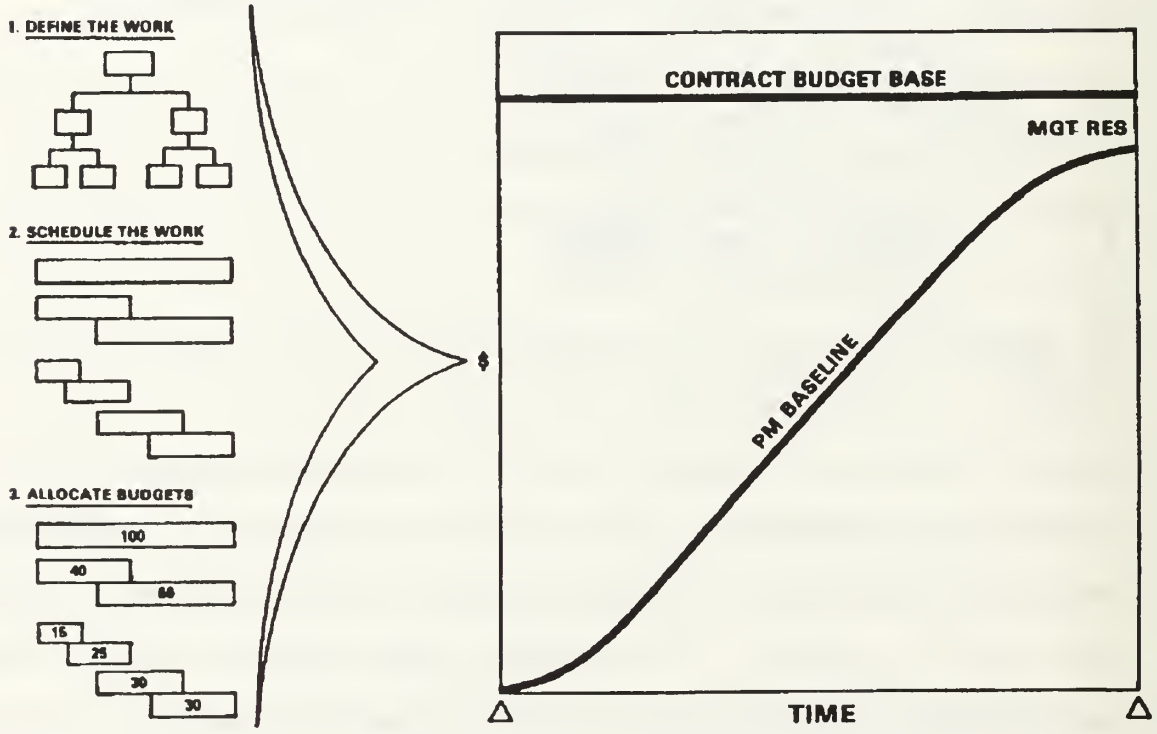

Figure 2. Establishing the PMB - A 3 Step Iterative Process [Ref. 31].

One of the most important measurements derived from the PMB is the estimate at completion (EAC), which is the bottom line, i.e., what the project will likely cost when it's completed [Ref. 14:p. 93]. For this to be reliable, however, both the scheduling and the budgeting systems must be formal

and disciplined to prevent arbitrary changes. Most projects have nearly continuous changes in the baseline but they must be controlled and result only from deliberate management actions. Therefore, it is essential to establish a PMB that defines a budget baseline for the original work, before the changes to the original work occur. This will allow the means to incorporate changes and keep revisions up to date.

Once the initial PMB is established to a degree where earned value measurement and customer reporting can begin, monitoring the variances is the critical next step. With the earned value concept, performance variances cause attention to be focused only on those areas or work packages that have exceeded reasonable, previously set limitations. These limits are called variance thresholds and cover both cost and schedule performance.

3. Consistent Earned Value Measurements

Some important terms must be defined before a description of the various earned value measuring techniques can be given.

BCWS - Budgeted Cost of Work Scheduled. This is the time-phased sum of the budgets of all work packages scheduled to be accomplished. This is equivalent to the PMB (performance measurement baseline).

BCWP - Budgeted Cost of Work Performed. This is the sum of the budgets of completed work packages and completed portions of open work packages, plus the amount of level of effort and apportioned effort scheduled to be accomplished in a given period of time. BCWP is also called Earned Value.

ACWP - Actual Cost of Work Performed. The sum of costs actually incurred and recorded in accomplishing work performed in a given period. ACWP includes direct and indirect costs.

BAC - Budget at Completion. The total sum of all budgets (BCWS) allocated to a contract, BAC is the end point of the performance measurement baseline.

EAC - Estimate at completion. A value (expressed in dollars or hours) that represents a realistic appraisal of the final cost of tasks when accomplished. It is the sum of all direct and indirect costs incurred to date plus the estimate of costs for all remaining work. EAC = Cumulative actuals (ACWP) + estimate to completion.

ETC - Estimate to completion. This is the BAC minus the sum of BCWP.

Consistent with the criteria approach, Government documents on C/SCSC do not prescribe "how" a contractor must measure performance or earned value. This is left up to the contractor and usually depends on the type of contract and the product or service to be delivered. There are just three rules or guidelines which apply to the calculation of earned value [Ref. 14:p. 119]:

- Performance measurements must take place at the lowest possible level, normally at the cost account level. Exceptions may be allowed.
- The calculation of earned value (BCWP) must be done using methods consistent with the way the plan (BCWS) was established originally, and in the manner in which the cost actuals (ACWP) are being accumulated.
- Once the BCWP is determined and reported to management and the Government, no retroactive changes may take place, except for the adjustment of legitimate accounting errors.

Techniques to measure the BCWP vary from contractor to contractor, and usually depend on the type of work involved in the contract and whatever is best suited for the firm. The

six most common methods, as described in Fleming's Guide, are described below.

- The 50/50 Technique. This can be used for work packages with a duration of no more than three accounting periods, preferably two maximum. Fifty percent of the planned value is earned when the activity starts, and the balance is earned when the effort is completed. This can also be modified to allow the percentages to vary - 25/75 or 40/60, etc. This technique was popular in the early days of C/SCSC, but its use has diminished in recent times.

- The 0/100 Technique. This approach is best applied to work packages that are scheduled to start and complete within one accounting period. Nothing is earned when the activity starts, but 100 percent is earned when it is completed.

- Milestone Technique. This approach works best when work packages will extend past three accounting periods. Objective milestones are established within a work package, and the assigned budget for the work package is divided up based on a weighted value assigned to each milestone. In those instances where there are no milestones in a given month, an estimate of the value of the work completed during the month may by allowed, as long as the original plan called for such estimates to be made.

- Percent Complete Technique. This approach allows for a periodic estimate of the percentage of work completed. This is done on a cumulative basis by the cost account manager. For example, if you are making 10 trailers and you have completed the frames for eight of them, and each frame is worth 10 percent of the value of a trailer, then you have an earned value of 80 percent of one trailer (8 X 10% = 80%).

- Equivalent and/or Completed Unit Technique. This method places a given value on each unit completed, or fractional equivalent unit completed. For example: a value of $25 per unit is assigned as the basis for setting both the budget value and earned value. If, in a certain month for a work center, the planned work is to complete 6 units, the BCWS is then $150 (6 X $25). If all six units are completed in that month, then the work center has earned $150 of earned value (BCWP). This approach works best when you have recurring effort (fabrication or assembly) and the effort will be performed in excess of two accounting periods.

- Earned Standards Technique. This method requires the establishment of standards for the performance of the tasks to be worked. Historical cost data, time and motion studies, etc., are all essential to the process of setting work standards. This technique is best used with repetitive type manufacturing work.

The current earned value position (BCWP) for a given contract, regardless of which technique is used, is simply the summation of all cost accounts which are completed or in-process, expressed in either dollars or hours. A simple determination of the estimate to completion (ETC) can be made by subtracting the BCWP from the total scheduled work or BAC. Then, if you add the ETC to the actual costs of work performed (ACWP) to date, you will have the contract's estimated costs at completion (EAC). However, this does not consider cost/schedule variances to date, which are needed for a more realistic trend analysis.

The EAC and trend analysis for decision making is what makes the earned value concept so useful, because it can be generated right from the start of work and continue throughout the contract period. The importance of this was reinforced by the current Under Secretary of Defense (Acquisition), Mr. Donald Yockey, who advocates the use of earned value procedures as an essential part of any PM early warning system [Ref. 29:p. 15].

D. EARNED VALUE REPORTING

The information generated from earned value calculations is normally reported to the customer on a monthly basis in one of two report formats - the Cost Performance Report (CPR) or the Cost/Schedule Status Report (C/SSR), depending on the contract value.

1. Cost Performance Report

The CPR is required for all major contracts defined by DODI 5000.2, part 11-B, as being significant. This monthly report displays baseline data for both cumulative and current period costs incurred. It includes cost and schedule variances, EAC, the Latest Revised Estimate (LRE), and the Management Reserve (MR). The CPR is used by the Government and contractor to monitor and assess cost/schedule status of a given program and provides a continuing forecast of the ultimate estimate of costs at completion compared to that originally budgeted.

2. Cost/Schedule Status Report

This report applies to contracts or work efforts that are not of sufficient dollar value to warrant a CPR. However, the contractor must be in a position to describe the baseline and many of the same items covered in C/SCSC. Because of this, the C/SSR is a less comprehensive and more flexible management report, which is more appropriate for smaller acquisitions. For example, the C/SSR does not require

performance reporting on a functional basis nor manloading projections. Only cumulative performance is reported in the C/SSR, rather than both current-period and cumulative performance, as the CPR requires. The most important difference between the CPR and the C/SSR is the calculations of the Budgeted Cost of Work Scheduled (BCWS) and the Budgeted Cost of Work Performed (BCWP). For CPR reporting, the BCWS and BCWP must be the result of direction summation of work package budgets. The C/SSR provides for the determination of these values through means other than work packages [Ref. 34:p. 7]. The specific methodology to be used is normally negotiated and should be accurately and consistently applied. Thus, the C/SSR gives the contractor greater flexibility of using internal performance measurement techniques than does the CPR.

The C/SSR was established in 1974 to fill a management void for smaller programs not requiring compliance with C/SCSC by providing compatible cost and schedule performance data with that generated on significant contracts. The report's intent is to provide a summary level cost/schedule performance data that will satisfy the PM's information needs from the same data base employed by the contractor for internal control purposes. Other objectives of the C/SSR are to:

- Improve management of small programs.
- Avoid management overkill on small programs (or on less-than-significant contracts of large programs).

- Avoid proliferation of "program unique" reports.
- Provide objective, integrated, and standardized cost/schedule performance reporting on contracts.

Generally, the C/SSR applies to contracts that: are over $2 million; over 12 months in duration; are not selected for CPR reporting; do not require C/SCSC compliance, and are not firm fixed-price contracts. Reporting of costs is normally at WBS level 3, but contractors must be able to report at a lower level if variance parameters are exceeded.

As stated earlier, the earned value concept enables the contractor to provide reliable estimates of cost and schedule at completion. The C/SSR provides monthly updates of this estimate based on performance trends and the latest forecast of future conditions. Since the Budget at completion (BAC) for the contract is the sum of all planned work along the contract budget baseline (PMB), the difference between the EAC and the BAC is the project overrun or underrun for the contract. Figure 3 presents a graphical example of the performance data required for these estimates and their relationships.

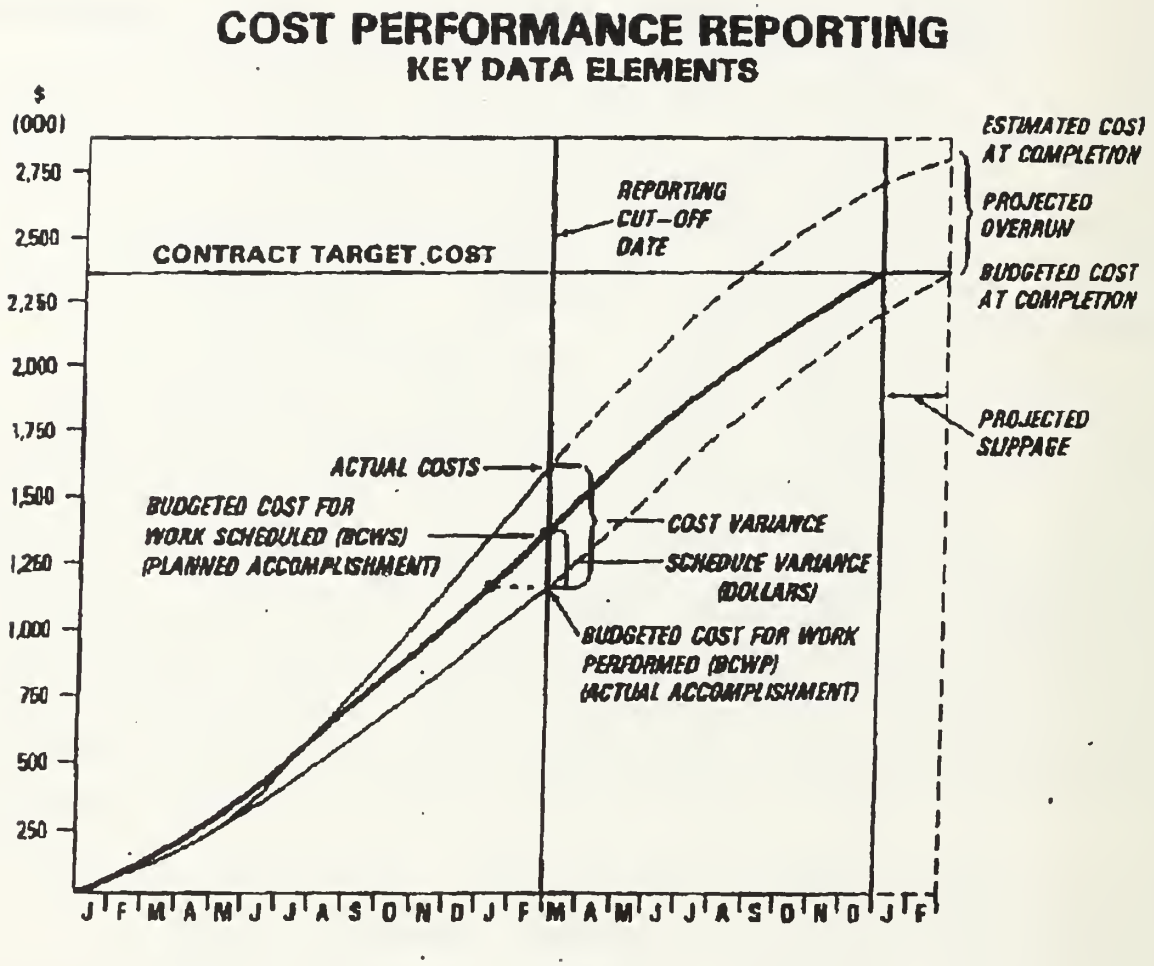

Figure 3. Performance data required and relationships for the EAC (Estimate at Completion) calculations [Ref. 31].

III. THE U.S. ARMY DEPOT SYSTEM

A. HISTORY/BACKGROUND

The US Army Depot System Command (DESCOM), with headquarters at Letterkenny Army Depot, Chambersburg, Pennsylvania, is a major subordinate command (MSC) of the US Army Materiel Command (AMC). Established in 1976, DESCOM commands and controls the Army's 11 depots and five depot activities. Most of the depots have their origins dating back to the 1940s, during the height of World War II.

The depots and depot activities are:

- Anniston Army Depot, Anniston, Alabama
- Corpus Christi Army Depot, Corpus Christi, Texas
- Letterkenny Army Depot, Chambersburg, Pennsylvania
- Savanna Depot Activity, Savanna, Illinois
- Lexington-Blue Grass Army Depot, Lexington, Kentucky (due to close under the Base Realignment & Closure Act (BRAC) of 1991)
- Mainz Army Depot, Mainz, Germany (closes under BRAC Act)
- Red River Army Depot, Texarkana, Texas
- Sacramento Army Depot, Sacramento, California (closes under BRAC)
- Seneca Army Depot, Romulus, New York
- Sierra Army Depot, Herlong, California
- Tobyhanna Army Depot, Tobyhanna, Pennsylvania
- Tooele Army Depot, Tooele, Utah
- Fort Wingate Depot Activity, Gallop, New Mexico
- Navajo Depot Activity, Flagstaff, Arizona
- Pueblo Depot Activity, Pueblo, Colorado
- Umatilla Army Depot Activity, Hermiston, Oregon

DESCOM employs approximately 28,000 military and civilians and manages an operating budget of about $2.3 billion

annually. The primary mission of the depots of DESCOM is to provide the maintenance, overhaul, and repair of all major Army systems, including tanks, howitzers, aircraft, combat and support vehicles, missiles, ammunition, and communication equipment. The mission also involves the modification, conversion, storage, and distribution of systems and equipments.

A recent addition to the mission of depots is that they are now allowed to manufacture/fabricate complete end items or systems in support of certain Army acquisition programs. This addition came about from a change to the Arsenal Act, which was included in the FY 1992 Appropriation Act. Essentially, this change provides for depots to perform as subcontractors to prime defense contractors, and also allows them to competitively bid for development and production-type contracts directly from Army acquisition program management offices. Before the Arsenal Act was changed, depots and arsenals were prohibited from manufacturing complete systems and thus competing with the industrial base, basically because the Government was not "in business to be a business." However, depots competing for contracts or performing as subcontractors still have to operate at cost only, or a "zero-profit" goal when awarded any contracts[1].

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[1]Technically, depots are not awarded "contracts" from other Government activities, but a Interdepartmental Memorandum of Agreement (MOA) is signed by the parties involved. The MOA provides authority to expend funds and to commence work.

In response to this new workload source, depots have formed "strategic business offices," led by a Competition Manager. The Competition Manager has the responsibility to monitor the Commerce Business Daily publication and other sources for Government solicitations that they could potentially bid for. They also assist in bid preparations and negotiations.

In addition to the Arsenal Act change, a DOD directive in 1991 has ordered that the Army Major Subordinate Commands (MSC) must now compete a portion of their maintenance workload with private industry. Before this directive, most of the Army's sustainment overhaul work[2] automatically went to the depot system. The customers reimburse the depots the cost of the overhaul and maintenance work. For FY 1993, the MSCs, the primary customers of depots, have estimated that $73 million worth of overhaul work will be competed between industry and Army depots. The procedures for this were published in May 1992 in the Joint Service Procedures for Public/Private or Public/Public Competition of Depot Maintenance [Ref. 32].

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[2]The life cycle of a system or piece of equipment has certain phases of effort, beginning with: 1. Research & Development, 2. Manufacturing/Production, 3. Operations & Support (Sustainment), and 4. Retirement (Disposal). Depots historically have performed mostly the sustainment workload of a weapon system.

B. FUNDAMENTALS OF DEPOT MAINTENANCE OPERATIONS

1. Work Organization and Procedures

The three depots that provided most of the information for this analysis (Sacramento, Letterkenny and Tobyhanna Army Depots) are basically organized the same way. Figure 4 shows the basic organization of most depots.

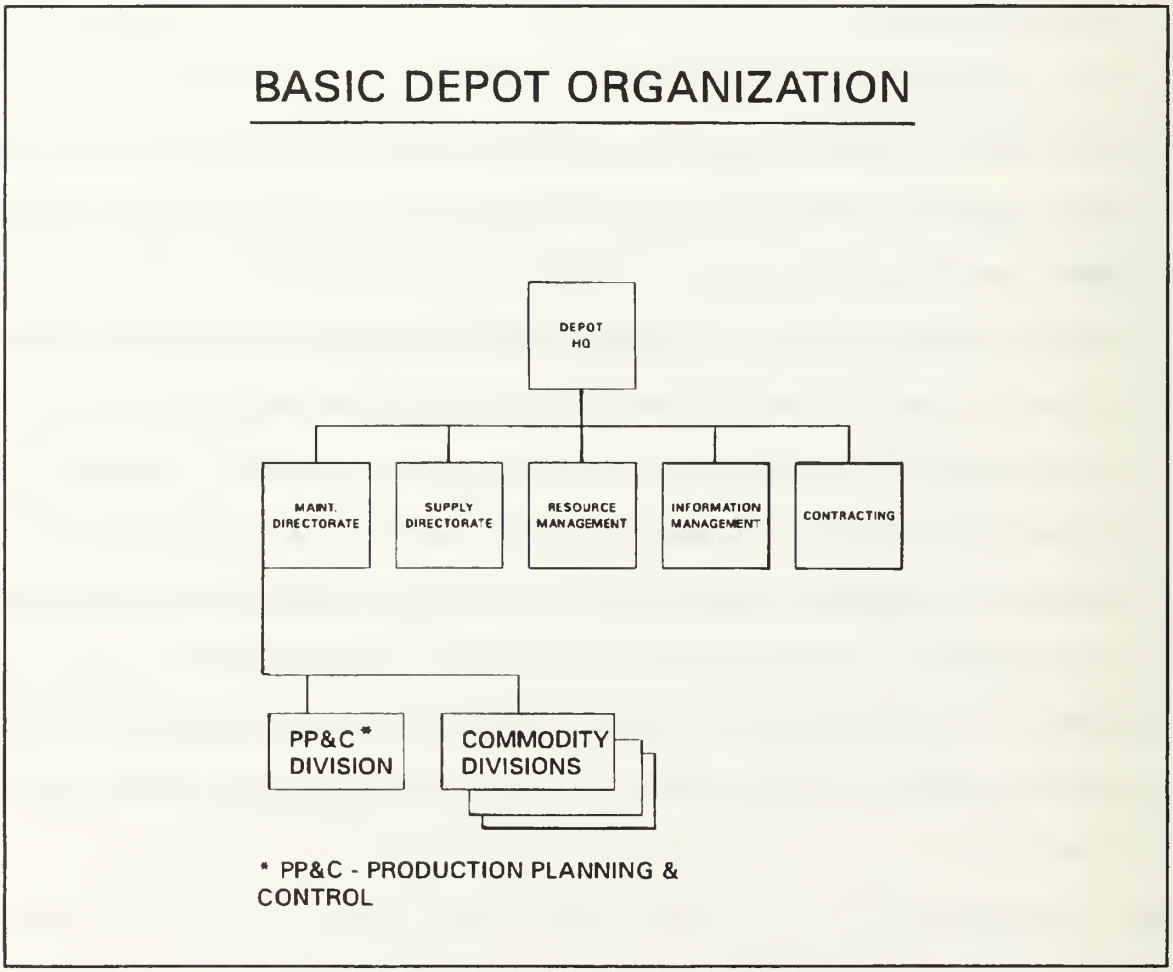

Figure 4. Generic organizational chart for Army Depots. Source: Developed by researcher.

The Maintenance Directorate is responsible for performing all overhaul, fabrication and maintenance related

operations for the depot. This includes the associated functions of production planning and control, and special projects. The various divisions under the Maintenance Directorate comprise the particular specialization of each depot.

Sacramento Army Depot (SAAD), for instance, specializes in communications-electronics items, complex laser and optics systems, multilayered circuit card fabrication and repair, fiber optics and cryogenic equipment. SAAD has the capability to produce sophisticated radar systems such as the Army's Firefinder Radar Kit. As such, SAAD has been designated as the Center of Technical Excellence (CTX) for the Firefinder Radar system.

The CTX Concept that DESCOM employs is a unique management concept to ensure integration of the complete depot industrial base in support of the total life cycle of weapon systems. Depots are designated as CTXs to support certain weapon systems that meet the following criteria:

- System is listed in the Army Modernization Information Memorandum (AMIM)
- System is characterized by high complexity
- Weapon/Item has significant impact on depot system
- Support to materiel developer requires dedicated manager
- Logistic support factors have considerable impact upon initial combat readiness of the system
- System will substantially impact fielded units
- System has high visibility at high levels of the Army

Personnel staffed in the CTX sections of depots provide direct liaison with the acquisition program management

offices during the development, production, and fielding of the weapon system. Currently, eight depots are designated as CTX for approximately 30 different weapon systems. However, once the system has completed the development cycle and is fielded, the standard depot maintenance commences and the CTX designation is normally terminated.

When a customer work requirement is accepted by a depot, it is assigned to the appropriate commodity division which is responsible for the project planning, tracking and reporting. This "prime shop," as it is referred, identifies all the individual tasks necessary to develop and/or to produce and deliver the product. Workload planning is done much in the same fashion as developing a Work Breakdown Structure (WBS), covered in Chapter II. The prime shop provides estimates of cost, start times, and completion times for those tasks for which it is directly responsible. For those tasks for that work from other functional elements of other commodity divisions, e.g., engineering drawings, welding, machining, painting, the PP&C division (Production Planning and Control) accomplishes the necessary coordination.

PP&C division personnel are responsible for coordinating and scheduling all tasks for each project. PP&C personnel tabulate the tasks, associated costs, and schedules for all depot functional elements necessary for each project. Each task (or work package, as it is called with the WBS) is assigned a Production Control Number (PCN) with associated

dollar amounts based on the estimates received from the work shops. Milestone charts and summary estimates of cost and schedule are prepared and projections of cost over time are presented in graphical form. As work proceeds on the work packages, expended manhours are charged against the appropriate PCN and by operational code, or "Op-code." Op-codes identify the section or shop that is performing the work being charged to the PCN. Use of op-codes and PCNs allows for the intersection of the WBS and the depot's organizational elements.

Parts and materials drawn from inventory or the supply division for each task are also charged against the PCN and op-code. Work shops record daily expenditures of manhours and materials per PCN into the automated information management system called SIMA (System Integration and Management Activity). The PP&C division tracks all the PCNs of a certain project to monitor progress. The PCNs of a project are tracked to one Procurement Request Order Number (PRON). The summations of all the PCNs theoretically should add up to the amount of the PRON, which represents the "baseline" for a certain project. It is through the PRON that actual funds are transferred from the customer to the depots.

Before work efforts are given to depots, there is a form of negotiation that takes place. Potential customers provide Statements of Work (SOW) and specifications to the depot, which in turn prepares an initial estimate on cost and

delivery schedule. Final details are worked out and once both parties agree on the cost of the project, a MOA (Memorandum of Agreement) locks the depot in on that price (normally a fixed-price arrangement). The funds are provided up front via the PRON, materials are ordered and work can begin. Any overruns on the project funds must be absorbed by the depot. In some instances, however, customers actually provide the additional funds for overruns. Since the depot and customers are both Government activities, funds come from the same source. Conversely, if the depot experiences an underrun, the funds usually stay with the depot. DESCOM resource managers claim that the overruns and underruns usually equal out over each fiscal year.

The major customers of the depots are the Army's Major Subordinate Commands (MSCs), e.g., the Communication and Electronics Command (CECOM), Missile Command (MICOM), and the Tank and Automotive Command (TACOM). Other customers are from the Army's Program Executive Offices, which control most of the Army's Program Management Offices (PMO). Program management offices are often collocated with the MSCs. Most single work projects accepted by depots average under $1 million; however, projects over $1 million are becoming more common.

2. Customer Cost and Schedule Reporting

Depot operations in the Depot System Command (DESCOM) are basically uniform in procedure under the Standard Depot System (SDS). However, reporting to its customers in Program Management Offices (PMO) is far from uniform. There are many "program unique" reports that depot project leaders provide to their corresponding PMO. The most common type of performance report is the "Funds Status Report." This report provides information on the total amount of funds received for a given work effort, the amount expended and the total amount remaining (also given in percentages), provided monthly or quarterly. An example of a typical Funds Status Report is presented in Figure 5.

Some Funds Status Reports go into detail on critical material expenses and most are accompanied with a Gantt Chart scheduling the planned start and completion dates of major tasks for the project. However, these reports and charts provide little indication of performance and interrelationships of the work tasks on the charts. In addition, the report provides no estimates of costs at completion nor if the project will be completed on time.

For example, the information in Figure 5 shows that approximately 54 percent of the funds are spent at the date of the report, but it does not show if 54 percent of the work was completed or not. Actually, the depot project leader was sure that 54 percent of the work was not completed because much of

PROJECT "X" FUNDING STATUS

28 May 1992

PRON: 1J27701900[redacted]1E

J0115L

AUTHORIZED FUNDS:		
RECEIVED Dec 1991		$1,000,000
RECEIVED Mar 1992		500,000
EXPENDITURES:		
Labor	$581,889	
Travel	2,359	
Parts	8,211	
PSpice Software	18,200	
Logic Analyzer	13,910	
Oscilloscope	10,154	
Printer	1,745	
TOTAL EXPENSE:	$636,468	
BACK ORDERS:		
GTT Software	$99,060	
Switching Modules	28,800	
Impedance Comparator	21,350	
Peak Power Analyzer	15,000	
RF HF Probe	1,900	
Peak PWR Sensor	1,400	
BACK ORDER TOTAL	$803,978	
NOR Surcharge	3,362	
PROGRAM TOTAL:	**$807,340**	
PROGRAM BALANCE:		**$692,660**

Figure 5. Typical project status report from Army Depots to Customer Program Management Office. Source: Sacramento Army Depot.

the spent funds to date were for material on order and not in process.

As stated earlier, all information regarding expenditures against PRONs via PCNs is input into the SIMA in the depot workshops. SIMA is a part of the bigger network

called the Standard Depot System (SDS). All depots operate under the SDS, which is more than just a computer network. SDS is also a form of standard operating procedure for most depot operations, including reporting procedures. SDS provides guidance on shop management and also reporting procedures. Most financial reporting from the depots is not actual reporting in the historical sense. Rather, resource management personnel from the depot and DESCOM are able to access the SDS network and gather information they need to generate their own reports. This process is very efficient because it requires only that the functional elements of the depot continuously input the resource data into the network. Unnecessary paper is eliminated.

SDS utilizes electronic data interchange (EDI) with depot headquarters, DESCOM in Letterkenny Army Depot, Pennsylvania, for the purpose of resource management and budgeting. At the same time, customers from the MSCs and PMOs can also access the network for certain levels of information. This process is actually another form of cost and schedule reporting. Customers with access to the network can inquire on the status of their projects via the "PRON" Report. An example PRON report is shown in Figure 6.

A PRON report contains a wealth of information concerning types of expenditures and the amount of funds remaining. However, the only indicator on the report that compares performance with funds spent is a line called "EQV-

```
  MD01 MAINT DEPOT LEVEL INQUIRY AS OF 92272-0933 FOR PRON E[redacted]2BB700EJ TERM=P13R
                          BASIC IDENTIFICATION                                CODES/INDIC
ACC-CLASS 21    12031    15E5E05P1210002562  623204                          MANAGER    9Y
AMS-CODE  732207AC5K00001050249 1UT   STK-ITM-NO 15008INGARS00               PERF-ACT   1P
CUS-OR-NO [redacted]11P10182R01         PROJ-OR  AO FAC-NAME TOBYHANNA       TYPE-FAC   1
ITEM-NAME [redacted] KIT                FY 92 SELLER IP AMCPRON E[redacted]2BB700EJ FIXED-PR
    QUANTITIES      ORIG               PROPOSED                DATES          NARRATIVE
MNT-AUTH        521  ORG    U-MT-FD-CST                 PG-RSP-DEP           PG-RSP-DEP
MNT-PROG        521  ORG    MT-AUTH-QTY                 PG-RSP-CMD           PG-RSP-CMD
EQV-PROD         65  ORG    MT-PROG-QTY                 LOCAL-RSP            LOCAL-RSP
ON-HAND                          INITIAL                INIT-DEPOT 92021 C-LOOP        0
COMPL-TD                U-MNT-FD-CST      14000.00      OBLIGATION 92021 SIMS          0
COMP-FFY          0     U-MT-TOT-CST      13999.97      LAST-OBLIG 92268 OMGT-INT      0
WIP             521     U-MNT-MHR           148.30      LAST-ACTIV 92269 SEL-MGT       N
SCRAP                            CARRY-IN               COMMITMENT 92021 APRV-OT       N
IN-EX-OR              0 AUTH-QTY                  0     CAN-REQ    00000 AUTO-AUTH
GR-MAINT            521 WIP-FND-CST               0     PGM-START  92244 IFP-IND       T
    MISCELLANEOUS       WIP-MHR                   0     PRON       92021 DADAC         0
AG-AC-NO                 0            MANYEARS          WORK-AUTH  92268 NO-BILL
NO-PI-CP              0 LIN       EF-AUTH       .00     PR-STA-RPT 92266 L-NO-ETF
IN-MH-IN              0 PDIF SPEG EF-PROG       .00        CONT-PRICE    ETF-LINE      0
STU-TRND              0 MRIS  007 EF-GROS       .00 UMNT              .00 REL-C-MNT D
M-DEP-N               0 F-MOD   Y EF-NET          0 AVUM              .00 PROJ-CD    ZCN
MSC-ANAL-CD  AEJ60                 PAGE  2  OF   5 P
 MD01 MAINT DEPOT LEVEL INQUIRY AS OF 92272-0933 FOR PRON E[redacted]2BB700EJ TERM=P13R
           UNIT-FUND UNIT-TOTAL  EXP-TD-FND  EXP-TD-TOT    ADDITIONAL COST INFO
MAINT      15488.25   15488.19     1303047     1309671 MNT-EXP-LMT        16000
MATL        6990.00    6990.00      686870      686870 PROG-FUND        8069378
OTHER        881.04     881.04        3510        3510 PROG-TOTAL       8069378
MSN-OH-AS   1670.93    1670.93      170327      172005 FUND-COMIT       8069378
MSN-OH-WS    736.75     736.75      104629      105769 FUND-AUTH        8069378
BASE-OPS     213.24     213.24        4899        6019 DELIV-FND              0
IND-MAINT   3483.84    3483.84      396140      401644 DELIV-TOT              0
IND-ROPS    1076.16    1076.16      121183      123870 WIP-FUND         1303047
   DL-MANHOURS          DL-COST            BILL        WIP-TOTAL        1309671
EXP-PR-FY         0  CIV-PU    3108.41 T-DT    1303047 UNFUND-DEP             0
CIV-PU       165.31 CIV         211628 PR-CY   1226560 UNFUND-RET      24217.00
CIV           11193 MIL-PU         .00 PR-FY         0 MIL-PER-RET            0
MIL-PU          .00 MIL              0                 MIL-SPT-OFC            0
MIL               0 OTHER        11068     OTHER       MIL-SPT-ENL            0
AUTH          86127              CODF-PY-CY          0 2-DEST-TRAN            0
PROG          86127              PSUR-RP-PT          0 INIT-ON-INV            0
EXP           11193              PSUR-EN-IT          0 PA-REP                 0
OT-EXP          851              U-MNT-RCT           1 ST-FND-REP             0
     PR-FYS                      REP-MO-SCH            ASSET-USE              0
FUND-COST         0                                    MATL-EX-RT           .00
TOT-COST          0                                    ACT-U-FCST           .00
                                   PAGE  3  OF   5 P
 MD01 MAINT DEPOT LEVEL INQUIRY AS OF 92272-0933 FOR PRON E[redacted]2BB700EJ TERM=P13R
        UNIT-FUND       BILL-TD    BLTD-PR-CY    BLTD-PR-FY
NOR          200.02            0            0            0                 PRICE
SURCHG       611.64            0            0            0
SSM-ASSMNT-PU          .00 SSM-ASSMNT-APPLD         0
FXDRIFPH          .00 FRAUTHMH               0

FY1   INDSCH   CMDSCH CD PRODSCH       CMPL      INDSCH   CMDSCH CD PRODSCH      CMPL
OCT        0        0 00       0          0  APR      0        0 00       0         0
NOV        0        0 00       0          0  MAY      0        0 00       0         0
DEC        0        0 00       0          0  JUN      0       50 03       0         0
JAN        0        0 00       0          0  JUL      0       50 03       0         0
FEB        0        0 00       0          0  AUG      0       50 03       0         0
MAR        0        0 00       0          0  SEP      0       50 03       0         0

FY2   INDSCH   CMDSCH CD PRODSCH                 INDSCH   CMDSCH CD PRODSCH
OCT        0       50 03       0             APR      0       21 03      50
NOV        0       50 03       0             MAY      0        0 00      50
DEC        0       50 03       0             JUN      0        0 00      70
JAN        0       50 03       0             JUL      0        0 00      70
FEB        0       50 03       0             AUG      0        0 00      70
MAR        0       50 03       1             SEP      0        0 00      70

                                   PAGE  4  OF   5 P
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Figure 6. Example PRON Report (Procurement Request Order Number) from a US Army Depot. Source: DESCOM Headquarters.

PROD," which stands for "equivalent-productions-units" completed to date. The report is laden with codes, letters and numbers, a sometimes confusing array of dollars, dates and quantities. The PRON report in the hands of a upper level manager, such as a Project Manager, would not be very useful because it does not contain any variances, estimates at completion or any other measures of effectiveness. Cost analysts from the MSCs and program offices normally are the ones who access the report and summarize expenditures and funds remaining for providing information to the Project Managers.

In summary, the depot cost and schedule reporting to program managers basically focuses on the expenditure of funds without relating performance to these expenditures. There is little standardization among reports to different programs, creating what is known as "program unique" reports.

Some depot managers contend that PMs are kept up to date on performance status of work efforts though quarterly IPRs (In-Process Reviews), which are normally conducted at the depot site. However, IPRs rarely reveal efficiency rates or cost/schedule trends that identify potential problems. In addition, current depot reporting methods do not include estimates of costs at completion of the work.

Estimates at completion (EAC) should concern the depot more than the PM because of the fixed-price "contract" commonly used within depots. The EACs and performance

measurements, which are provided with the C/SSR, are vital in view of today's declining budget in the Army. Depots are now entering a new realm of what is called "acquisition work," rather than just "sustainment work." Now, cost/schedule and performance information is crucial to successful implementation of a new weapon system. The number of depots performing acquisition work is significantly increasing. Examples of various acquisition work efforts currently at some Army depots are provided in the following section.

C. SIGNIFICANT ACQUISITION EFFORTS AT ARMY DEPOTS

The mission of Army depots in recent years has been expanding into many different areas of military support, including acquisition work. Depots are now performing more than just routine sustainment of weapon systems and are becoming "partners" in the acquisition process of weapon systems.

Within the scope of this thesis, "acquisition efforts" are defined as work outside the spectrum of a depot's "historical" overhaul and sustainment work. The equipment and weapon systems in the "historical" category have already been fielded and are in the operations and support phase of their life cycle. Conversely, an "acquisition effort" is restricted to work performed in support of the development and/or production phase of an equipment/weapon system. This can also include major modifications of fielded weapon systems. An easy way to

categorize significant acquisition efforts at Army depots is by the type of funds used to pay for the efforts. Those efforts that are funded with Research, Development, Test and Evaluation (RDT&E) category funds and Procurement category funds are to be considered acquisition efforts. In addition, an acquisition effort will also be managed by a program management office, which is separate from the Major Subordinate Commands. Most depot operations are funded with the OMA (Operations and Maintenance Appropriation) category of funds and are not managed by a PM. These are not considered acquisition efforts.

A good example of a significant acquisition effort is the M109A6 PALADIN Self-Propelled Howitzer program at Letterkenny Army Depot (LEAD). This program calls for upgrading and modifying most of the older fleet of M109 chassis, many of which were fielded over 20 years ago. Part of the program is funded with OMA funds and the other with procurement funds, but all funds are managed by the PALADIN Product Manager at Picatinny Arsenal, New Jersey. LEAD is working in conjunction with BMY, Inc. (prime contractor), for this program. The initial work of stripping and cleaning the older howitzer chassis is performed by LEAD and then the chassis are sent to BMY in York, Pennsylvania. LEAD also assembles the modification kits that will be installed by BMY. The total estimated cost of the PALADIN work to be performed at LEAD is $226.5 million for the period from FY 1992 to FY 1998.

C/SCSC or the Cost/Schedule Status Report (C/SSR) is not currently being used at LEAD for this work effort. In addition, the depot project leaders of the PALADIN effort at LEAD were not familiar with earned value or the C/SCSC since it is not required. Although the PMO does receive the typical monthly Fund Status Report from LEAD, they stated that it would be much more helpful if they received a Cost Performance Report (CPR) or the C/SSR. However, the PALADIN PMO personnel are very pleased with the work that LEAD is doing and the PMO does receive monthly CPRs from BMY.

Another example of a depot acquisition effort is the Air Force managed joint program called JTIDS (Joint Tactical Information Distribution System) currently ongoing at Sacramento Army Depot (SAAD). This is a development program in which SAAD is developing 29 Test Program Sets for the Integrated Family of Test Equipment (IFTE). Currently, it has been funded with RDT&E funds of $5.2 million for the period from FY 1992 to 1994. Although the depot project leader said that the formal earned value concept is not being used for this effort at the depot, he did have a complete breakdown of tasks and schedules for project control.

Several important acquisition efforts are also ongoing at Tobyhanna Army Depot (TOAD). One is the SINCGARS (Single Channel Ground and Airborne Radio System) and another is a project in support of the Army Data Distribution System (ADDS). The depot project leader for the ADDS project was

familiar with C/SCSC but indicated that they are not using it. The depot managers provide the usual funds status reports with cost breakdowns and milestones charts but no performance variance analysis. Even though the Project Manager for the ADDS is satisfied with the work of TOAD, he is not satisfied with the funds status reports from TOAD. The ADDS PM strongly supports the use of the C/SSR for the work at TOAD and suggests that all Government field activities performing "acquisition efforts" should implement the C/SSR. His program has already successfully implemented the C/SSR for his testing at the Electronic Proving Ground, Fort Huachucha, Arizona [Ref. 36:p. 8].

During the research for this thesis, only one work effort among the entire Depot System was found to be using the C/SSR and the earned value concept. This was the Firefinder Radar program at Sacramento Army Depot (SAAD). This program, which began in March 1992, marked the first time the earned value concept was used within the DESCOM. The nearly $20 million, three-year program called for the manufacture of 54 radar kits and an associated program for the overhaul of five existing radar kits. This work effort will be examined more closely in Chapter IV of this thesis.

Today, there are numerous acquisition efforts ongoing at most Army depots and the efforts will continue to grow in numbers and in dollar value. Generally, when a depot has been designated as a CTX (Center of Technical Excellence) for a

certain weapon system, it will most likely be considered a significant acquisition effort. Appendix B lists the current locations and weapon systems of DESCOM's Centers of Technical Excellence.

D. SUMMARY

DESCOM is a very large and complex military organization with a long and proud history. As the mission of the depots evolves with the changing role of today's Army, so must depot operating procedures and management techniques. In the face of direct competition with industry for a declining workload, depots must explore new ways of doing business. In the critical area of cost/schedule control and reporting, depots should examine the methods that their competitors are using. Industry has been using C/SCSC concepts for over 25 years and its use is still growing. History has shown many management techniques that have been proven successful in the commercial sector become adopted for the Government's use. Supply management and inventory procedures are two such examples. The next chapter further explores areas for Army depots to use the concepts embodied in the C/SCSC.

IV. IMPLEMENTATION OF EARNED VALUE TECHNIQUES

A. INTRODUCTION

This chapter introduces the procedures necessary for a Program Manager (PM) to implement the earned value techniques via the Cost/Schedule Status Report (C/SSR) with a private contractor. The Cost/Schedule Management of Non-Major Contracts (C/SSR Joint Guide) (Draft) provides excellent guidelines for implementing the management techniques necessary for the C/SSR [Ref. 9]. Though this Joint Guide only focuses on implementing the C/SSR with private contractors, the procedures are analyzed for their applicability with Army depots. Only the C/SSR is analyzed for its applicability with Army depots because it is unlikely for a depot to receive a work effort above the thresholds requiring a CPR.

A compatibility analysis follows that looks at how compatible the standard depot operating systems would be with meeting the requirements of the five categories of C/SCSC criteria. Attention is focused on Sacramento Army Depot, which was the first depot to implement the earned value concept for a work effort (Firefinder, version seven Radar program). This chapter concludes with a summary of issues

that Army depots must address before the concepts of C/SCSC can be implemented.

B. PROCEDURES FOR C/SSR IMPLEMENTATION WITH A CONTRACTOR

1. Evaluation of Management Needs

The first step in C/SSR implementation should be an assessment of the necessary information needed for satisfactory control of a project. The PM must ensure that the cost and schedule reporting requirements fit the particular management needs. The extent of technical risk, potential for cost growth and funding limitations are some factors to be considered [Ref. 9:p. 2-1]. The PM must ensure that implementing the C/SSR will contribute to successful program management. The PM should evaluate if the contractor's current methods of cost and schedule reporting will meet the needs of the program.

2. Solicitation Clause

The Defense Federal Acquisition Regulation Supplement incorporates clauses for standardization of C/SSR requirements throughout the DOD [Ref. 9:p. 2-1]. The C/SSR is a standard data item (DI-F-6010) of the CDRL (Contract Data Requirements List). The solicitation document should, at a minimum, stipulate: (1) the need for the contractor to have a written summary of the management procedures for generating reliable cost and schedule data for submission in the C/SSR; (2) a preliminary Work Breakdown Structure (WBS), and (3)

provisions for access to pertinent internal documentation [Ref. 9:p. 2-1].

3. WBS Preparation

The PM should prepare a preliminary WBS to be included in the solicitation. This summary level WBS identifies the levels and elements for which cost and schedule performance data will be reported and provides the framework for planning and collecting contract-related information. The preliminary WBS also helps the contractor in defining all the necessary tasks to complete the project and in the preparation of the detailed CWBS.

C/SSR reporting should be limited to level three or higher of the CWBS [Ref. 9:p. 2]. The reporting level is of critical importance because there is a significant increase in the effort (and cost) to report at each successively lower WBS level. In addition, a preliminary WBS is important because it provides an opportunity for the contractor to expand on the preliminary WBS to propose a better organization of work.

4. Establishment of Reporting Requirements

Certain aspects of the C/SSR, such as the CWBS, specific elements to be reported, reporting frequency, and the initial submission date are normally negotiated between the PMO and contractor. Most importantly, the performance measurement approach must be agreed upon, in particular, the method for determining the budgeted cost of work performed

(BCWP). The primary area of concern when measuring BCWP is the measurement of the work-in-process, i.e., work packages that have started, but are not completed as of the report cut-off date [Ref. 9:p. 2-4]. This is important because the BCWP provides a basis upon which to compare the variations from the scheduled work, trends analyses, estimates at completion, and progress payments.

5. Plant Survey

The PM should visit the contractor to survey the contractor's information management system and performance measurement techniques. The contract should provide for visits and discussions of the contractor's management practices including appropriate briefings and demonstrations of their cost/schedule information system. During the visit, the PM and CAO (Contract Administration Office) should achieve a basic understanding of the methods of planning and scheduling work, controlling the resources applied to the contract, measuring cost/schedule performance, authorizing work and incorporating changes to the contract.

6. Software Support

A major reason why PERT/Cost and C/SCSC had such a hard time catching on in the 1960s was due to inadequate computer systems used during this period. C/SCSC techniques require many computations and have a high degree of input/output demands. The card punching and slow co-

processors of the 1960's technology were not conducive to using C/SCSC. The use of the earned value techniques was ahead of its time.

Today there is ample computer hardware and software available to amplify the utility of the earned value management tool, such as personal computers, local area networks, electronic mail and electronic data interchange (EDI). There are also several software packages made just for cost/schedule management and reporting. A recent evaluation of the top four software programs concluded that the "Performance Analyzer" software provided the best overall utility for cost and schedule management [Ref 33:p. 29].

Performance Analyzer (PA) is designed to improve the efficiency of the analysis and reporting process associated with CPRs and C/SSRs. The software generates reports that can be sent to the PMO via EDI. Because of this efficient transfer of information, the PMO and contractor can communicate critical cost and schedule progress and can converge on problem areas early on. Whatever the software support, whether its PA or another comparable program, the PM should provide this to the contractor for internal or external use.

7. Training Support

Training is a necessity for successful C/SSR implementation if a contractor has never used the C/SSR. Even

if a contractor has previously used the C/SSR (or CPR), the PM should still assess the contractor's level of competency with C/SSR requirements. This can be done by reviewing past contracts' performance and time since last using the C/SSR. Training support can range from providing educational materials and assistance visits, to formal classroom lectures. However, the best training on C/SSR comes from experience, so if necessary, the PM should provide periodic assistance throughout the contract period.

8. Surveillance

The contract administration office is responsible to ensure that the contractor is meeting his requirements and that the C/SSR reflects actual conditions and addresses actual/potential cost and schedule problems [Ref. 9:p. 2-11]. The authority for CAO surveillance is the contract, but the basis of surveillance activities should be defined in a Memorandum of Agreement (MOA) between the CAO and the PM. The PM and the CAO should document and maintain the results of any surveillance actions for future purposes.

At a minimum, surveillance actions should consist of [Ref. 9:p. 2-11]:

- Monitoring the progress of any corrective actions previously required of the contractor.
- Receipt, analysis, and processing of the C/SSR to include reconciliation of the C/SSR data to the contractor's internal data.
- Ensuring that C/SSR clause provisions are complied with.

- Monitoring the contract to assure the contractual requirements and negotiated reporting requirements are met.
- Verifying that the contractor identifies and explains significant changes to the budget plan and incorporates changes in a timely manner.
- Verifying the reasons for and impact of the cost/schedule variances on which they are required to report.
- Ensuring that the C/SSR data are reconcilable with data on other reports.

In summary, the procedures listed above provide a foundation for implementing the C/SSR at a contractor's facility. However, the procedures to implement C/SSR are not all inclusive and will vary among programs, depending on the nature of the work required.

C. C/SSR COMPATIBILITY WITH THE STANDARD DEPOT SYSTEM

The following analysis addresses the compatibility of current SDS procedures at three Army depots with the requirements of the five major criteria categories of C/SCSC. For this analysis three depots, Sacramento Army Depot (SAAD), Letterkenny Army Depot (LEAD), and Tobyhanna Army Depot (TOAD) were used as a research base. Only three were chosen since DESCOM stated that SDS basically operates the same for all depots.

Only the summarized requirements of the five categories of C/SCSC, instead of the individual criteria, were used for the analysis. This is because implementing the C/SSR does not

require a formal Governmental validation of the criteria, as does the CPR.

1. Organization Category

The ability to define the work effort and assign responsibility for work is the requirement for the criteria in the "organization" category. It was found that Army depots do organize work in a fashion very similar to the Work Breakdown Structure (WBS) requirements listed in MIL-STD 881A. In addition, Army depots have many skilled and experienced managers able to define work efforts and assign responsibility. All three depots analyzed for this thesis would easily comply with this category of criteria.

Though the WBS is commonly used at Army depots, SAAD experienced difficulties with the reporting levels for the C/SSR. A depot manager for the Firefinder project commented that the WBS reporting levels were not well defined, because initially cost data were gathered and reported down to levels four and five of the WBS. This created problems in having to expend too much effort in gathering cost information on the lower level packages. The normal reporting level for the C/SSR is only to level three.

2. Planning and Budgeting Category

The basic requirements for this category include the ability to plan, schedule, budget, and authorize the work. Depot project leaders, in conjunction with the PP&C

(Production Planning & Control) division of the three depots perform these tasks, except for budgeting, on a daily basis.

At LEAD and TOAD, the PP&C division prepares printouts for each shop's scheduled work load for a 10-week period, which is updated weekly. This detailed report is called a "Shop Completion Schedule," and aids the shop managers in the daily operations of their particular shops. Among the major items included in the printout are work breakdowns by tasks and op-codes, estimated total manhours for each task, incurred manhours-to-date and remaining manhours-to-complete for each task.

It is important to note that though the Shop Completion Schedule assists a shop manager in authorizing work efficiently, the report does not provide any cost information. No material costs, indirect costs or direct labor costs are included in the "shop" report. The Chief of the PP&C division at LEAD stated that all depots basically use the Shop Completion Schedule in the same way [Ref. 43]. Thus, depot managers are usually not accustomed to establishing budgets for individual work packages or cost accounts.

To be able to assign the budgets for C/SSR purposes, depot managers need only to "dollarize" the individual work packages into their cost accounts. To "dollarize" a work package means to convert the estimated direct manhours and material costs into a single total, in terms of dollars. The depot project leaders of the Firefinder were able to

accomplish the "dollarizing" to establish the Performance Measurement Baseline (PMB) with only minimal training. The assignment of budgets to individual work packages/cost accounts is a change from the normal depot planning methods. However, as the SAAD Director of Maintenance commented, this would be a change for the better [Ref. 38]. Not only does the assignment of budgets create a better sense of costs at all levels, it requires more careful planning upfront, which usually leads to greater efficiency throughout the course of the project.

3. Accounting Category

The accounting system of an organization must be able to accumulate costs of work and material to satisfy the requirements of the accounting category of C/SCSC criteria. Each depot has an elaborate accounting system for tracking expenditures per PRON (Procurement Request Order Number). With regards to the C/SSR, however, the accounting system (called "financial management system" in depots) is not linked to the WBS (work breakdown structure) of a work effort. As a result, the depot project leaders for the Firefinder project had to estimate the actual cost of work performed (ACWP) for some work packages/cost accounts.

Initially, their primary problem was estimating costs of materials for open work packages. They overcame this by using an overnight batch report that the SDS can generate if

requested. The report is called "Parts Analysis Report," which shows the costs of material drawn from inventory per PCN (Production Control Number). The Firefinder project leaders could cross reference these PCNs with the 'op-codes' to estimate the costs of materials consumed by each open work package [Ref. 39]. This method could be accomplished at each of the three depots.

4. Analysis Category

Managers must be able to compare planned versus actual costs and analyze the variances to meet the criteria requirements of this category. Only with training and experience in the area of earned value measurements can a person become skilled in variance analysis. The SDS provided scant information necessary to compare planned versus actual costs for individual work packages.

Due to their inexperience in measuring earned value (Budgeted Cost of Work Performed), the depot managers of the Firefinder project often equated the actual cost of work performed (ACWP) to the planned or budgeted cost of work performed (BCWP), when, in fact, the actuals were significantly different. As a result, there were no cost variances in these cases indicated by the report, thus making the report unreliable.

The analysis category of C/SCSC criteria requires an appropriate amount of training to conduct proper variance

analysis. The analyses of cost/schedule performance data are where the "pay-offs," or the most benefits are received from using the C/SSR. With proper and reliable data from a C/SSR, a manager can identify signs of difficulties impacting from technical, material, or personnel problems. The C/SSR also provides work efficiency trends as early as the second or third monthly report.

Note that the earned value concept embodied in the C/SSR does not solve problems in and of itself. Rather, it provides early indications of problems and potential problems for management's attention. Currently, Army depot personnel could not satisfy this category of criteria without a certain amount of training and education. The software program Performance Analyzer can greatly aid in the analysis of planned versus actual expenditures. With C/SSR training and using the Performance Analyzer, each depot analyzed could easily provide reliable variance and trend analyses.

5. Revisions Category

This category of criteria requires an ability to incorporate changes in the program and to be able to develop estimates of final costs. Sacramento, Letterkenny and Tobyhanna Army depots are accustomed to changes in the scope-of-work because of their relationship with their Government customers. It is much easier for the Government to invoke a change proposal at an Army depot than it is to invoke a change

with a private contractor because of the contractual difference. With a private contractor, a PM has to go through the formal contract administration channels for a contract modification. With a depot, a PM can just send a memo with an adjustment of funds for the change. The point is, Army depot managers are experienced at incorporating revisions to work efforts.

With regards to developing estimates of final costs, all three depots fall short. Interviews of depot managers revealed that depots do not normally provide estimates at completion (EACs) unless the customer requests them. Even then, the estimates of final costs are not based on performance-to-date or indices of variances from the planned work. Thus, providing there are no changes in the scope of work, a depot estimate at completion usually does not change from the initial estimate.

One point of view may contend that revising EACs is not necessary because the work effort is a firm fixed-price "contract". On the other hand, with a firm fixed-price arrangement, the depot leadership should be more concerned with estimates at completion (EAC) because it is the depot that will absorb all cost overruns.

Additionally, in view of today's tighter budgets, both the depot and customer should be concerned with EACs to ensure that all forecasted costs are budgeted for. The program manager, as a customer of an Army depot, has to be concerned

with estimated final costs because a significant increase from the initial estimate invariably results in a later delivery schedule. This is one of several reasons why all the program office personnel interviewed for this thesis would prefer that the three depots use the C/SSR for their programs. By using the C/SSR, current estimates at completion (EAC) are provided monthly.

Interviews with depot personnel and DESCOM Headquarters indicate that depot managers do not emphasize cost or schedule trends, variance analysis or EACs. This finding parallels a 1983 Presidential private sector survey on cost control which concluded that "there appears to be insufficient emphasis on cost trending and forecasting. As a result, when overruns are identified it is often too late to take corrective measures [Ref 37]."

D. IMPLEMENTATION OF C/SSR AT SACRAMENTO ARMY DEPOT

The Special Projects Division, SAAD, became the first DESCOM depot to implement the C/SSR and thus use the earned value concept. SAAD had been the Center of Technical Excellence (CTX) designate for the Firefinder Project (formerly under the Radar Program), Fort Monmouth, New Jersey. The Radar PMO released a Request For Proposal (RFP) for full and open competition requiring the manufacture of 54 AN/TPQ-36 Firefinder radar kits and the overhaul of five older version models. The Special Projects Division of SAAD and Hughes

Aircraft (the original manufacturer) submitted proposals for the work. The solicitation document included the standard C/SSR clause, among the other standard items normally found in RFPs for open competition among private industry. The contracting officer for the PMO determined that SAAD offered the best value and thus awarded the contract to SAAD in March 1992. It was a firm fixed-price "contract", with an estimated total cost of $16.7 million over a three-year period.

According to DODI 5000.2M, section 20, a firm fixed-price contract does not require a CPR or C/SSR unless the program manager determines it necessary for cost/schedule visibility. In this case and against the wishes of the depot leadership, the PM insisted that the depot provide a C/SSR on a monthly basis [Ref. 42]. An Interdepartmental MOA was signed in March 1992, marking the beginning of the implementation of the earned value concept at SAAD.

Only one or two depot managers were familiar with C/SCSC and the earned value concept when work started on the Firefinder project. As a result, problems developed almost immediately, primarily with establishment of the Performance Measurement Baseline (PMB) (defining, scheduling, and budgeting work packages). Depot managers were accustomed to defining, scheduling, and estimating the total manhour and material requirements for projects, but were not accustomed to assigning budgets (in dollars) to each work package.

The Director of Maintenance at SAAD indicated that the planning aspect of C/SSR was one of many positive aspects about the C/SSR concept. According to this official:

> It requires our first line managers to think and measure everything in terms of dollars. Just being aware of the dollar cost of work instead of thinking in terms of manhours will help us become more competitive. This frame of mind probably will be one of the earlier obstacles we must hurdle [Ref. 38]

The Radar program office sent experienced program analysts to the depot to assist and train depot personnel on C/SCSC concepts and C/SSR procedures. The program analysts were confident that the depot could provide the C/SSRs with minimal changes from their current operating and management systems. This pioneering effort by the Special Projects Division called attention to itself from the Office of the Assistant Secretary of Defense (Comptroller). In April 1992, a representative from the Comptroller's office came to the depot to assist in the training effort.

It was not until June 1992 that the Special Projects Division first received the PA software from the Firefinder project office. The software program enabled the depot to submit its first C/SSR, which was sent via the Electronic Data Interchange (EDI). The depot managers said that the information for the C/SSR was much easier to manage using the PA program.

The pioneering implementation of the C/SSR at SAAD would have been an ideal test case for examination of the long term

feasibility of using C/SCSC concepts at all Army depots. Unfortunately, due to implications of the closing of Sacramento Army Depot[3], work on the Firefinder project slowed down and was eventually transferred to Tobyhanna Army Depot (TOAD) in November 1992. A decision to continue the C/SSR requirement at TOAD has not been made as of February 1993.

A significant problem encountered with the impending closure of SAAD was the loss of trained personnel. The managers who were most knowledgeable with the project, received the C/SCSC training, and set up the initial baseline, left the depot without being able to sufficiently train their successors. As a result, project control of C/SSR data deteriorated. The method of measuring the BCWP (budgeted cost of work performed) was of critical importance, and no one totally understood what method was being used.

Certain fundamentals of implementing the C/SSR at Army depots and the compatibility of the Standard Depot System (SDS) were nonetheless brought out during the short attempt at SAAD. Fundamentals such as training and education, the accounting system link to the WBS of a project, and certain issues involved with incorporating a new procedure within an organization can be noted as lessons learned.

The absence of a link between the financial management system of SDS and the WBS should be further addressed. This

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[3]Sacramento Army Depot is scheduled to close in January 1994 under the Base Realignment and Closure Act (BRAC) of 1991.

affects the computations of actual direct labor costs for C/SSR purposes. The WBS reporting level for the Firefinder project was at level three, which in the organizational structure was the sub-PCN level. The financial management system of SDS only provided cost visibility to the PCN level. This caused the depot project managers to manually tabulate labor costs of each sub-PCN. The information to do the tabulating was not difficult to obtain but it was sometimes time consuming. The Chief of the Automation Division at SAAD stated that it would only require minor modifications to the SDS to provide cost visibility down to the sub-PCN level [Ref. 40].

DESCOM currently has a SDS Modernization Program ongoing that may provide managers the ability to query the SDS and tailor their own reports. To improve the utility of the C/SSR, DESCOM should include upgrades to the SDS that can provide cost visibility to the sub-PCN level. However, using the C/SSR, a depot would be afforded the flexibility of improving their own internal control methods to generate the necessary information.

E. ANALYSIS OF C/SSR IMPLEMENTATION PROCEDURES AT ARMY DEPOTS

The same eight procedures to implement the C/SSR at a private contractor were analyzed with respect to their applicability to Army depots. When "contracting" with an Army depot, a PM may use a less formal approach than with a private

contractor. Nonetheless, a PM's concern for effective cost and schedule control should be one of his highest management priorities. For review, the eight procedures are:

- Management Need Evaluation
- Solicitation Clause
- WBS Preparation
- Establishment of Reporting Requirements
- Plant Survey
- Software Support
- Training Support
- Surveillance

1. Management Need Evaluation

The evaluation of management needs should be an automatic task regardless of whether the contract involves a private firm or an Army depot. The PM will have to consider his program's technical risk, potential for cost growth, and funding limitations, just as he would if contracting with a private firm. In addition, when "contracting" with an Army depot, the PM should also consider the possibility of follow on support from the depot. By investing today in the implementation of the C/SSR at the depot, future support programs also will benefit. Thus, the management need evaluation procedure also applies to Army depots when implementing the C/SSR.

2. Solicitation

Army depots would have difficulty responding to a solicitation that required written procedures for generating reliable cost/schedule data for the C/SSR. This is because depots have never used the C/SSR and do not have personnel familiar with the requirements of the C/SSR. However, by working with the PMO and contracting officers, depot managers could prepare bid responses that relate to the requirements of the data necessary for C/SSRs. Most depots already have the capability with their present information systems to generate the necessary data for C/SSRs, and only need to restructure the data into proper format and organization. The requirements for C/SSR and the training for its use could be a part of the "contract" or MOA negotiations.

3. WBS Preparation

With regards to the next procedure, PM preparation of a preliminary WBS, would also apply to Army depots. This is because a preliminary WBS is a common sense approach to successful initiation of any work effort, regardless if the C/SSR is used or not. A summary level WBS clearly communicates the basic requirements of the work effort and identifies the elements for which cost and schedule performance data will be reported. The preliminary WBS also helps the depot in defining all the necessary tasks to

complete the project and in the preparation of the detailed CWBS.

The reporting level is of critical importance because there is a significant increase in the effort (and cost) to report at each successively lower WBS level. Therefore, C/SSR reporting should be limited to level three or higher of the CWBS [Ref. 9:p. 2]. The depots visited for this research were familiar with, and usually organized their work efforts under the guidelines of MIL-STD 881A (Work Breakdown Structure Manual).

4. Establishment of Reporting Requirements

If the evaluation of the management needs (step one) determined that the C/SSR is required, certain elements of the report should be included in the "contract". Items such as the CWBS and reporting level, reporting frequency, initial submission date, and the performance measurement approach should be the major considerations. Many of these reporting requirements that should be established are the same as if implementing the C/SSR at a contractor and for the same reasons. Exact guidelines cannot be provided because reporting requirements will vary according to "contract" value and content. For example, a work effort in the $80 to $100 million range requires more management attention than a contract for $5 million. Similarly, a project with low risk will demand less attention than a project involving a high

technical risk. Thus, the PM should base the reporting requirements on his evaluation of management needs.

5. Plant Survey

A visit to the Army depot is an important step for a PM for several reasons. One reason is that the PM can survey the depot's information management system, performance measurement techniques and his project's relative priority among the total depot workload. Other reasons are that it allows the depot personnel to meet the PM face-to-face, and the PM can observe the capabilities of the depot. Therefore, a plant survey should be accomplished if implementing the C/SSR at a depot.

6. Software Support

Most Army depots are automated under the Standard Depot System (SDS) and are linked to the locations of most Army program offices. Thus, installing software programs that aid in compiling C/SSR data, such as Performance Analyzer (PA) would be a nominal task and should be done. However, an appropriate amount of training with the software program would be required to ensure proper implementation and use of the C/SSR. The Defense Systems Management College (DSMC), Fort Belvoir, Virginia, can provide assistance in the use and installation of the PA software.

7. Training Support

As noted with the C/SSR implementation with a contractor, training of depot personnel is also vital when using the C/SSR. Besides the assistance visits and briefings a PM can provide Army depot personnel, there are other alternatives available. The Defense Systems Management College also offers many types of correspondence courses in the area of Earned Value and C/SCSC.

The main point of this procedure is that training is critical when using the C/SSR. Without upfront training, the implementation process will most likely fail or require an extended period before the benefits of the C/SSR are realized.

8. Surveillance

Many of the same surveillance actions recommended for a PM implementing the C/SSR with a contractor also apply when "contracting" with an Army depot. Critical C/SSR surveillance actions at an Army depot include:

- Monitoring the progress of any corrective actions previously required of the depot.
- Verifying that the depot identifies and explains significant changes to the budget plan and incorporates changes in a timely manner.
- Verifying the reasons for and impact of the cost/schedule variances on which they are required to report.
- Receipt, analysis, and processing of the C/SSR to include reconciliation of the C/SSR data to the contractor's internal data.

In addition, a PM should require the depot to report any significant changes to internal operating procedures that may affect C/SSR reporting.

F. OTHER ISSUES INVOLVED WITH IMPLEMENTING THE C/SSR AT ARMY DEPOTS

Two other significant issues should be addressed before implementing earned value techniques in Army depots. These are resistance to change and top level support.

1. Resistance to Change

Change in an organization has always been a delicate undertaking and is a subject that has been thoroughly studied. However, using earned value techniques and the C/SSR in depots may not be such a radical change. Theoretically, using the earned value concept is only a formal enumeration of certain basic principles of good management.

Education and training play a big role in the change process. All personnel involved with the C/SSR should attend training to become acquainted with the criteria, implementing procedures and the benefits of its use. Once the C/SSR is in place and used routinely, the benefits normally outweigh any training costs [Ref. 27:p. 68]. In addition, once an organization's management information system has been approved for using C/SSR, it usually does not need to be reevaluated. It should be noted that SAAD personnel received training on C/SCSC concepts, but only after work was underway. Ideally,

the training should have been conducted prior to the actual start of work.

It takes a significant amount of time for a change to take hold inside an organization. Many problems SAAD experienced may not occur at other depots because of the unique effects of the impending closure of the depot had on its operations. SAAD did not actually have enough time to work the C/SSR into its normal operating procedures. It should be noted that some companies can take several years to incorporate the earned value concept. The Communication Systems Division of Hughes Aircraft took over five years to overcome resistance to change before fully implementing the C/SCSC concepts [Ref 41]. Today the Communication Systems Division uses C/SCSC techniques for all work projects, even if it is not required by contract.

2. Top Level Support

SAAD's implementation of C/SSR did not originate from the command level of the depot as a new depot reporting procedure. Instead, using the C/SSR was resisted by top management until it was finally decided that the C/SSR would be used. The depot mid-level managers had to spearhead this "new" cost and schedule control technique without initial command support. Critical to any successful implementation of a change is top level involvement and commitment.

G. SUMMARY

The Program Manager procedures for C/SSR implementation at an Army depot are basically the same as for C/SSR implementation at a private contractor's facility. The differences are only the degree of formality involved in contract implementation. However, Army depots may require additional training support from the program office because of the "resistance to change" issue mentioned above.

Analysis of the compatibility of the SDS with the five categories of C/SCSC indicated that the three Standard Depot Systems (SDS) are currently only compatible in the organization and revisions categories. However, with manager training and some experience with the concepts of C/SCSC, depots can also meet the requirements of the planning and budgeting, and analysis criteria categories.

For the SDS to be compatible with the accounting category of criteria, a link from the financial management system to a project's WBS would have to be developed. The flexibility of the C/SSR should allow the organization to improvise, using existing procedures to generate the required information. The depot managers of SAAD's Firefinder project demonstrated this by adapting the available information from the SDS to gather needed cost information.

The C/SSR implementation at SAAD also revealed several important points. The main point is that the C/SSR can be implemented in Army depots without major modifications to

their current automation systems or operating procedures. However, to make it less of an administrative burden to compile cost data, minor modifications that link the accounting system to a project's WBS would be required. Specifically, labor and material cost visibility down to the sub-PCN level should be available from the SDS user terminals for the depot project leaders.

Another critical issue associated with SAAD's experience with the C/SSR is that it demonstrated how important training and education is when incorporating a change. The Firefinder project leaders of SAAD had many difficulties in establishing a performance measurement baseline. Many of these problems may have been alleviated had training on C/SCSC concepts begun earlier.

As noted from the three depots researched, DESCOM must address the issues of resistance to change and top level support before a decision to implement the C/SSR is made. For an Army depot to use the C/SSR effectively, commitment and support, from DESCOM Headquarters to the depot leadership, will be the key to success.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

1. General Conclusions

As a result of this thesis research it is concluded that U.S. Army depots should use the C/SCSC concepts when performing significant acquisition efforts. The primary reason for implementation of C/SCSC techniques at Army depots is for improvement in controlling the cost and schedule of acquisition programs. There are also two other significant benefits of using the earned value concept at U.S. Army depots:

- C/SCSC techniques aid in program control, provide early identification of problems, and help to minimize schedule slippages and cost overruns.
- The reports generated from the C/SCSC techniques provide reliable information on cost and schedule status to the customer for decision making purposes.

As the amount of work at Army depots is being reduced due to military cutbacks, competition with industry has increased. To be competitive, Army depots must catch up with industry in not only modernization of equipment and facilities, but also with management techniques. Though Army depots have Strategic Modernization Plans for upgrading their facilities and equipment, they also must attempt to keep pace with industry in the area of management and cost control. The

defense industry has already been using C/SCSC concepts for over 25 years.

2. Specific Conclusions

The following is a summary of specific conclusions determined from the research and analysis of this thesis:

a. Army Depots Should Use The C/SSR For Most Of Their Acquisition Efforts.

The C/SSR is more flexible and less extensive than the CPR and is more suitable to Army depot operations. The CPR requires that the budgeted cost of work scheduled (BCWS) and the budgeted cost of work performed (BCWP) be calculated as a direct summation of work package budgets. The C/SSR, however, permits the determination of the BCWS and BCWP through any reasonably accurate, consistent, and mutually agreed to means. The flexibility of the C/SSR eases the problem of the depot's financial management system not linking with the WBS by being able to estimate some portions of the totals.

Another reason why Army depots should use the C/SSR is that most acquisition efforts performed by depots are under the thresholds for using the CPR. The recommended lower thresholds for using the C/SSR are for efforts over 12 months in duration and over $2 million, which more closely resemble the costs of many depots work efforts.

b. The Cost/Schedule Performance Reports that Depots Provide to Customers are Deficient in Satisfying Management Needs

This conclusion is based on interviews with Program Management personnel, and from analyzing the current depot cost/schedule reporting methods of the three depots (SAAD, TOAD and LEAD). Depot Fund Status Reports typically show only program funds spent and funds remaining. No comparisons of planned versus actual spending, performance analysis, nor any indications of estimates of final costs were provided from the depot reports. Implementation of the C/SSR would provide the PM all this information monthly, including the ability to identify problem and potential problem areas.

B. RECOMMENDATIONS

It is recommended that DESCOM (Depot System Command) incrementally integrate the use of the Cost/Schedule Status Report (C/SSR) into the Standard Depot System (SDS) of depot operating procedures. C/SSR implementation should be accepted and promoted by the top depot leadership and supported down to shop manager level. Education and training is the key to a successful implementation of any type of change. The following list summarizes the major recommendations of this research:

- Depots performing acquisition work should use the C/SSR as a standard report for all work efforts estimated to last over 12 months in duration and over $2 million.

- DESCOM should include in their modernization of the SDS, provisions to link the financial management system with the Work Breakdown Structure of the depot acquisition projects.

- Depots should incorporate the Performance Analyzer software (or comparable) to aid in using the C/SSR.

- DESCOM should invest in team education and training programs on C/SCSC and the C/SSR at all depots involved with acquisition type work. The Performance Management Division of the Army Materiel Command Headquarters and the Defense Systems Management College can provide assistance in this area.

C. RECOMMENDED AREAS OF FUTURE RESEARCH

Areas recommended for future research include exploring the feasibility of using C/SCSC concepts at other DOD field activities involved with acquisition efforts. In particular, Navy and Air Force depots should be researched.

APPENDIX A. COST/SCHEDULE CONTROL SYSTEMS CRITERIA

The following delineates the 35 criteria of C/SCSC, as listed in DODI 5000.2, part 11-B-1.

1. Organization

   a. Define all authorized work and related resources to meet the requirements of the contract, using the contract work breakdown structure (WBS).

   b. Identify the internal organizational elements and the major subcontractors responsible for accomplishing the authorized work.

   c. Provide for the integration of the contractor's planning, scheduling, budgeting, work authorization and cost accumulation systems with each other, the contract work breakdown structure, and the organizational structure.

   d. Identify the managerial positions responsible for controlling overhead (indirect costs).

   e. Provide for integration of the contract work breakdown structure in a manner that permits cost and schedule performance measurement for contract work breakdown structure and organizational elements.

2. Planning and Budgeting

   a. Schedule the authorized work in a manner which describes the sequence of work and identifies the significant task interdependencies required to meet the development, production, and delivery requirements of the contract.

   b. Identify physical products, milestones, technical performance goals, or other indicators that will be used to measure output.

c. Establish and maintain a time-phased budget baseline at the cost account level against which contract performance can be measured. Initial budgets established for this purpose will be based on the negotiated target cost. Any other amount used for performance measurement purposes must be formally recognized by both the contractor and the Government.

d. Establish budgets for all authorized work with separate identification of cost elements (labor, material, etc.).

e. To the extent the authorized work can be identified in discrete, short span work packages, establish budgets for this work in terms of dollars, hours, or other measurable units. Where the entire cost account can not be subdivided into detailed work packages, identify far term effort in larger planning packages for budget and scheduling purposes.

f. Provide that the sum of all work package budgets, plus planning package budgets within a cost account equals the cost account budget.

g. Identify relationships of budgets or standards in work authorization systems to budgets for work packages.

h. Identify and control level-of-effort activity by time-phased budgets established for this purpose. Only that effort which cannot be identified as discrete, short span work packages or as apportioned effort may be classed as level-of-effort.

i. Establish overhead budgets for the total costs of each significant organizational component whose expenses will become indirect costs. Reflect in the contract budgets at the appropriate level the amounts in overhead pools that are planned to be allocated to the contract as indirect costs.

j. Identify management reserves and undistributed budget.

k. Provide that the contract target cost plus the estimated cost of authorized but unpriced work is reconciled with the sum of all internal contract budgets and management reserves.

3. Accounting

a. Record direct costs on an applied or other acceptable basis in a manner consistent with the budgets in a formal system that is controlled by the general books of account.

b. Summarize direct costs from cost accounts into the work breakdown structure without allocation of a single cost account to two or more work breakdown structure elements.

c. Summarize direct cost from the cost accounts into the contractor's functional organizational elements without allocation of a single cost account to two or more organizational elements.

d. Record all indirect costs which will be allocated to the contract.

e. Identify the bases for allocating the cost of apportioned effort.

f. Identify unit costs, equivalent unit costs, or lot costs as applicable.

g. The contractor's material accounting system will provide for:

(1) Accurate cost accumulation and assignment of costs to cost accounts in a manner consistent with the budgets using recognized, acceptable costing techniques.

(2) Determination of price variances by comparing planned versus actual commitments.

(3) Cost performance measurement at the point in time most suitable for the category of material involved, but no earlier than

the time of actual receipt of material.

(4) Determination of cost variances attributable to the excess usage of material.

(5) Determination of unit or lot costs when applicable.

(6) Full accountability for all material purchased for the contract, including the residual inventory.

4. Analysis

a. Identify at the cost account level on a monthly basis using data from, or reconcilable with, the accounting system:

(1) Comparison of budgeted cost for work scheduled and budgeted cost of work performed;

(2) Comparison of budgeted cost for work performed and actual (applied where appropriate) direct costs for the same work; and

(3) Variances resulting from the comparisons between the budgeted cost for work scheduled and the budgeted cost for work performed and between the budgeted cost for work performed and actual or applied direct costs, classified in terms of labor, material, or other appropriate elements together with the reasons for significant variances.

b. Identify on a monthly basis, in the detail needed by management for effective control, budgeted indirect costs, actual indirect costs, and cost variances with the reasons for significant variances.

c. Summarize the data elements and associated variances listed in subparagraphs 4.a.(1) and (2), above, through the contractor organization and work breakdown structure to the reporting level specified in the contract.

d. Identify significant differences on a monthly basis between planned and actual schedule accomplishment and the reasons.

e. Identify managerial actions taken as a result of criteria items in paragraphs 4.a. through 4.d., above.

f. Based on performance to date, on commitment values for material, and on estimates of future conditions, develop revised estimates of cost at completion for work breakdown structure elements identified in the contract and compare these with the contract budget base and the latest statement of funds requirements reported to the Government.

5. Revisions and Access to Data

a. Incorporate contractual changes expeditiously, recording the effects of such changes in budgets and schedule. In the directed effort prior to negotiations of a change, base such revisions on the amount estimated an budgeted to the functional organizations.

b. Reconcile original budgets for those elements of the work breakdown structure identified as priced line items in the contract, and for those elements at the lowest level in the program work breakdown structure, with current performance measurement budgets in terms of changes to the authorized work and internal replanning in the detail needed by management for effective control.

c. Prohibit retroactive changes to records pertaining to work performed that would change previously reported amounts for direct costs, indirect costs, or budgets, except for correction of errors and routine accounting adjustments.

d. Prevent revisions to the contract budget base except for Government directed changes to contractual effort.

e. Document internally the changes to performance measurement baseline and notify expeditiously the procuring activity through prescribed procedures.

f. Provide the Contracting Officer and the Contracting Officer's authorized representatives with access to the information and supporting documentation necessary to demonstrate compliance with the cost/schedule control systems criteria.

APPENDIX B. DEPOT CENTERS OF TECHNICAL EXCELLENCE DESIGNATIONS

Anniston Army Depot

- M1/M1A1 Abrams Tank
- Hellfire Missile System
- Army Tactical Missile System

Corpus Christi Army Depot

- AH-64 Apache
- UH-60 Blackhawk
- Light Helicopter Airframe and Power Train (LHX)

Letterkenny Army Depot

- Howitzer Improvement Program: M109 Howitzer (Paladin)
- Patriot Missile System
- Hawk Missile System

Lexington-Blue Grass Army Depot

- COMSEC Equipment
- Fiber-Optic Guided Missile

Red River Army Depot

- Bradley Fighting Vehicle System: M2/M3
- FISTV V: M981 Fire Support Team Vehicle

Sacramento Army Depot

- Guardrail V
- Firefinder Radar Kit: AN/TPQ-36/37

- Light Helicopter and Avionics (LHX)

Tobyhanna Army Depot

- SINCGARS Regency Net
- AN/TTC-39, TYC-39, and DGM
- Integrated Family of Test Equipment
- DSCS
- Joint Stars, ASA/ENSCE
- Space Communications

Tooele Army Depot

- Heavy Expanded Mobility Tactical Truck (HEMTT)
- Armored Combat Earthmover (ACE)
- High Mobility Multipurpose Wheeled Vehicle (HMMWV)
- Family of Medium Tactical Vehicles (FMTV)
- M939 Trucks
- Heavy Equipment Transporter System (HETS)

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